POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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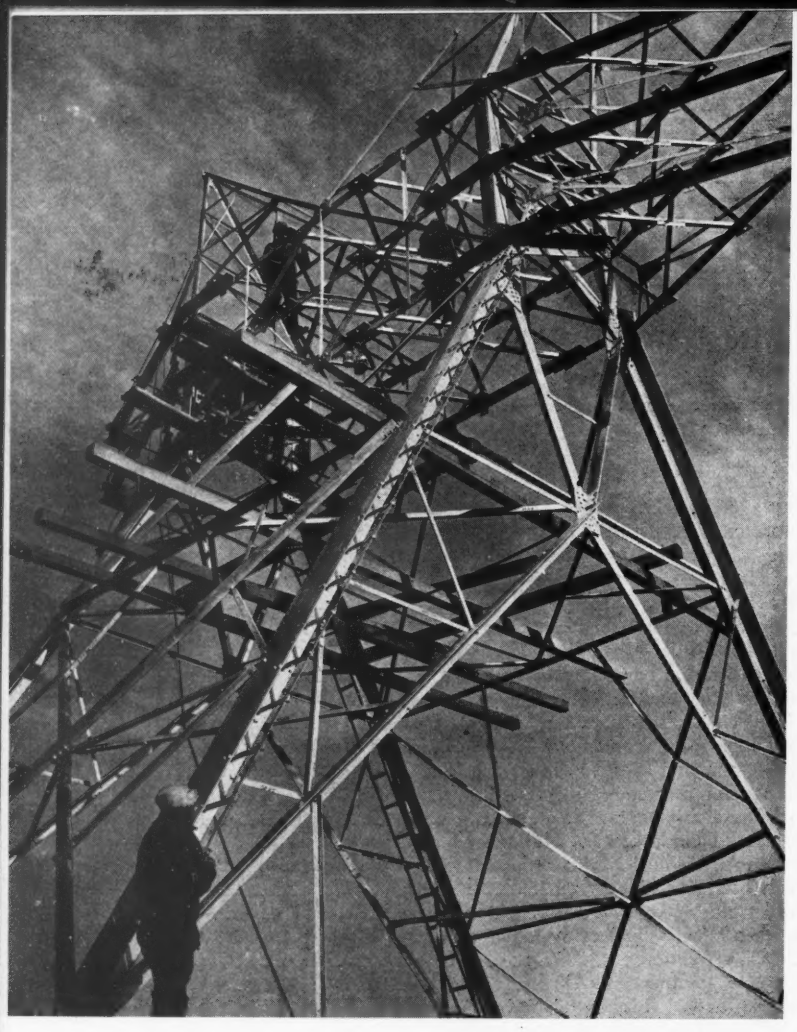


Construction of one of the steel river crossing towers for the transmission line supplying power for the dredges and tunneling operations for the Ft. Peck Dam. This project being built in eastern Montana will control the flow of the entire length of the Missouri River.

INTERCONNECTION

FEW THINGS illustrate better the advantages of interconnections than the structural steel towers on which high voltage conductors are carried over long stretches of open country. Made of relatively light members, numerous cross braces and interconnections between the main supporting elements tie the entire framework into a rigid, self-supporting structure; reliable, capable of sustaining great loads and economical in the use of material. It is as though the towers symbolized the electrical transmission systems they support, for in the same way that mechanical interconnections strengthen steel towers, so electrical interconnections strengthen and augment the scope of electrical transmission and distribution systems. Interconnection implies coöperation and coöperation always tends to enhance good qualities and to suppress or diminish bad ones.

Interconnection has received attention ever since adjacent electrical systems approached each other at sufficiently close range to enable interconnection to be effected and in the quarter of a century just passed which marks the major development of our transmission systems, interconnections have been made in all parts of the country. The map on page 158 shows the extent of these interconnections. Despite this apparent coördination between systems, the problems of interconnection have not all been solved particularly from the social standpoint. Thus far interconnections have been made largely on the basis of the benefits to be derived by the individual systems involved in each case, benefits in nearly all cases having to do with the profits resulting to the owners of the respective systems. There is a larger, social aspect to interconnections, however, one intimately related to the welfare of the people and the resources of the nation as a whole and this phase of the problem is now beginning to receive attention. It is our intention to bring before you various aspects of the interconnection problem. The article on interconnections on page 157 of this issue is concerned largely with the evolution and development of the existing system, but we expect to present further discussion of the question in future issues.

Future technical development is, of course, intimately related to this question. During the past few weeks some startling electrical developments in this field of transmission have been announced and, as in the case of anything new, there has been much discussion on both sides. In the report of the winter meeting of the American Institute of Electrical Engineers which appears in this issue some of this discussion is presented. Whether the direct current transmission scheme proposed has all the advantages its proponents claim for it or whether it is doomed to failure by the numerous obstacles and disadvantages its opponents see in it, is something only time will decide but the subject is one of great technical and social interest. Indeed the whole question of power—energy, is one that is of tremendous social significance and any solution of our social problems must sooner or later involve terms of power and energy, particularly electrical energy.

WITH THE EDITORS

Inquisition

WHAT GOOD anybody hopes to accomplish by public posting and disclosure of the details of incomes of citizens and corporations, it is difficult to discover. These facts have always been available to any government officials who have legitimate reasons for wanting them, but to spread them for the examination of racketeers, kidnappers, competitors and the merely curious is an infringement of privacy that is fraught with limitless possibilities for mischief. The law requiring such posting would seem to have been passed carelessly, with no thought of possible consequences. It is possible for Congress to repeal it promptly, before posting is made, and it will probably be done if the Department of the Treasury and the President ask such action. If the sentiment of tax payers and those who report incomes is made evident, in opposition to this inquisitional law, the harm may yet be prevented. But that sentiment must be made evident to our representatives in Congress, to the Treasury Department and to the President by letters or telegrams of protest. Letters to daily papers will help also. And, when filing the pink slip, write on it, "Filed under protest."

There is no need for and there are many reasons against this inquisition in regard to private affairs and it is time that citizens voice their objections to petty persecution initiated for political purposes.

Leadership in this matter is being undertaken by Sentinels of the Republic, an organization of which Raymond Pitcairn is national chairman, with offices at 1830 Land Title Bldg., Philadelphia, Pa. Coöperation by the methods outlined above will aid in getting the present law repealed and in preventing the passage of like laws in future.

Central Station Rehabilitation

MUCH HAS been said during the last few years concerning the improvement and rehabilitation of industrial plants and many instances have been cited to show the advantages of such rehabilitation work. Not so much has been said about the rehabilitation of central stations, however. There are, of course, good reasons for this; in the first place central stations had reached a high stage of development in the years immediately preceding the depression, and there was less room for improvement than in the case of the average industrial plant. Then, also, the central station load had fallen off considerably and it was possible to carry this reduced load on the latest and most efficient units on the system.

During the past year and a half, however, the central station load has been creeping upward, due in great measure to the increased domestic load. As a consequence, the central stations are approaching a condition where it will be necessary to use more of their total generating capacity and since this involves the use of less efficient equipment than that represented by the newest units, the question of improvement is one that is bound to come up in the very near future.

As an example of what can be accomplished in this direction, the recent rebuilding of Connors Creek stations of the Detroit Edison Co. is excellent. This station built in 1914 operated at an average heat rate of around 19,000 B.t.u. per kilowatt hours. Compared to the newer stations on this system which have heat rates of around 13,000 B.t.u., this station was relatively inefficient, so about two years ago the engineers of the Detroit Edison Co. decided to rebuild the station with the object of bringing its heat rate in line with that of Trenton Channel, Delray and other stations on the system.

The first step in this rebuilding program has just been completed and the manner in which it was accomplished and the excellent results obtained by the work forms a most interesting and valuable story—one which speaks eloquently of the skill and resourcefulness of the engineers who did the job. The kind of engineering involved in an instance of this kind is decidedly different from that displayed in the construction of a new station. It requires careful study to determine which of the old equipments shall be discarded and how to adapt certain other equipment to new conditions while all during the construction program the plant must be kept in operation. The way in which the Connors Creek station was rebuilt will be described in detail in a forthcoming issue, but the job is cited here as an example of what is possible in this field. There are many central stations all over the country with heat rates of 19,000 B.t.u. or over which might well consider a similar rehabilitation program. The equipment in these stations, as was the case at Connors Creek, is still in perfect operating condition and suitable for many more years of service, but an accurate engineering analysis of its operating cost might indicate that it would be profitable to scrap a considerable portion of it.

Modernization

DO YOU KNOW that practically all lines of power plant equipment has passed through an equipment revolution during the past three or four years? If you do not, or if you do, but have neglected to take advantage of it, you will find it a pleasant and valuable pastime to compare, point-by-point, your old equipment with the new designs. You will be astonished, not only at the technical advances and increased standardization intended to cut down costs and maintenance but at the restraint these industrious and ingenious manufacturers display in carrying on modestly instead of shouting their advances from the housetops.

Modern Power Plant *Serves*

Located in Quiet Country a Few Miles from the Hudson, this Hospital for Psychopathic Cases Depends upon a Power Plant for Light, Power, Heat and Hot Water. By Charles W. McBreen, Chief Engineer

ROCKLAND STATE HOSPITAL, near Orangeburg, N. Y., is one of the most modern of the large group of hospitals for psychopathic cases developed by this state in recent years, and was originally planned to care for about 6000 patients and employes. It is located in the open country and comprises a group of about 70 buildings covering an area of nearly 250 acres. The hospital comes under the Department of Mental Hygiene of the State of New York, F. W. Parsons, M.D., Commissioner, and is under the direct supervision of Russell E. Blaisdell, M.D., Medical Superintendent. It was designed and built by the Department of Public Works, of the State of New York, W. E. Haugaard, Comissioner of Architecture.

The power plant of an institution of this size must furnish an unfailing supply of light, power, heat and hot water to this group of buildings under all conditions of service, since no other source of supply is available and any major interruption to any service might have serious consequences. Reliability of service was therefore the most important consideration in the design of the plant and this has been assured with very little if any sacrifice in operating efficiency. While the power plant proper is just a good example of standard design for a medium pressure installation, the extensive heating and water distribution system has a number of novel and interesting features.

Four water tube boilers of the vertical bent tube, four drum type each of 835 hp. rated capacity are installed. Each boiler is set separately with 10-ft. firing aisles at sides and between units. There are two units on each side of the boiler room with ample space between fronts. The building is of modern construction and provided with large windows for lighting and ventilation. There are two brick stacks, each 210 ft. high, each pair of boilers being connected to a separate stack. Forced draft is supplied by four engine driven blower units of the slow speed paddle wheel type arranged in pairs, each unit having enough capacity to operate two of the boilers at slightly above double rating. Fan units are located in a separate room on the boiler room floor level. It will be noted that each pair of boilers constitutes a separate steam generating unit, having enough capacity, with high rating operation, to supply steam required to meet the maximum demand of the entire institution. This arrangement, with the double loop system of high pressure steam piping installed, reduces to a minimum chances of interruption to steam supply from the boilers.

Coal is delivered to the plant in cars on an elevated trestle and fed by gravity to a track hopper, from which it is delivered by an apron conveyor to the crusher. This delivers to a bucket elevator and this to a scraper conveyor, which distributes the coal to a bunker extending the full length of the boiler room. From the bunker, weighed coal is delivered to the stoker hoppers by a traveling weigh larry of one ton capacity. Yard storage space for about six months' supply of coal is provided.

Each boiler is fired by a seven retort gravity underfeed stoker having an active grate surface of 100

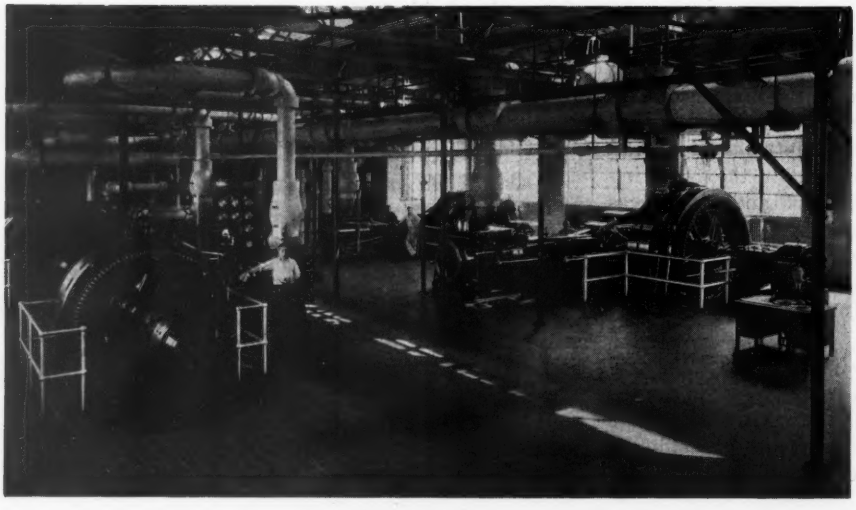


Fig. 1. A general view in the engine room of the Rockland State Hospital plant.

Four direct-connected engine generating units supply three-phase current at 2400 v. Steam piping is arranged in the double return loop system with full expansion bends.

Rockland, N. Y., State Hospital

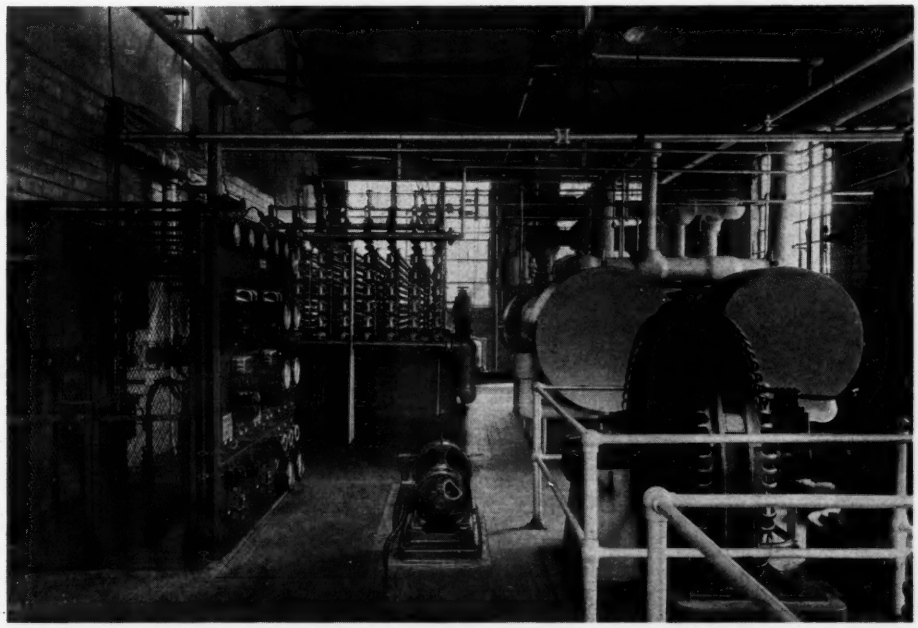


Fig. 2. Refrigeration machines, Rockland State Hospital

sq. ft. and equipped with steam operated double dump grates. The furnace volume is 2.1 cu. ft. per rated boiler horsepower which is ample for burning high grade semi-bituminous coals at moderate rates of combustion. While the ratio of grate to heating surface is rather above the average, it is satisfactory for the grade of coal used, with moderate combustion rates. Boiler settings are insulated and steel encased, and all observation and inspection doors are of an approved air tight pattern. Boilers are equipped with feedwater regulators and mechanical soot blowers, also boiler meters which record steam flow, gas flow and stack temperatures, and the plant has one CO_2 recorder so connected that any boiler in operation can be connected to it.

As is the case with any plant in which the heaviest demand for steam is for heating, there is a wide variation between summer and winter steam outputs, the mid-winter coal consumption being more than double that in summer. There is also considerable variation in hourly load at all seasons of the year, as the electric demand fluctuates widely because of intermittent operation of several large induction motors, and steam output is affected by sudden demands for live steam for laundry and kitchens. During the off heating season, loads are safely carried with one boiler, while during about six months of the heating season, two units are operated, but during the heating season peak of two or three months, it is found to be more economical, as well as safer to operate three units, though loads can be carried by two in an emergency.

Electric Generating Equipment and Auxiliaries

The four electric generating units are all of the same make and type, differing only in size. Engines are high speed, four valve with Corliss type valve gear and inertia governors of the remote control type. Engines are direct connected to three phase, 60 cycle, 2400 v. generators of the revolving field type with direct connected 125 v. exciters.

One unit is of 250 kv-a. capacity, two of 500 kv-a. and one of 781 kv-a. Initial steam pressure is 140 lb. gage and back pressure is from zero to 10 lb. maximum. The engines have enough reserve capacity to carry full electric loads at unity power factor which is very nearly attained at times of peak load, due to the high proportion of noninductive load carried.

Main steam piping is arranged in the double return loop system to carry steam to the engine room in duplex headers, and each main engine is connected to each header with full expansion loops, so any complete interruption to steam supply to the main engines is practically impossible, unless the plant is completely wrecked. All pipe is extra heavy with vanstone joints, and is well drained, with a large vertical steam separator at each engine throttle.

The smallest of the three units was installed more to provide for generation of power during the first stages of construction of the hospital, and now that nearly all the buildings have been completed, is not operated to any great extent, except during summer valley load periods. It is probable that this unit will be replaced by a much larger unit in the near future, for which there is ample space. As additional insurance against service interruption, and to steady voltage regulation, a separate motor driven exciter has been installed, with enough capacity to furnish exciting current for all the generating units, installed or contemplated.

Auxiliary Equipment

This is all located in a special pump space between the boiler and engine rooms. The open feedwater heater is so placed that there is a head of 30 ft. on the feed pump suction. The heater is of the V-notch

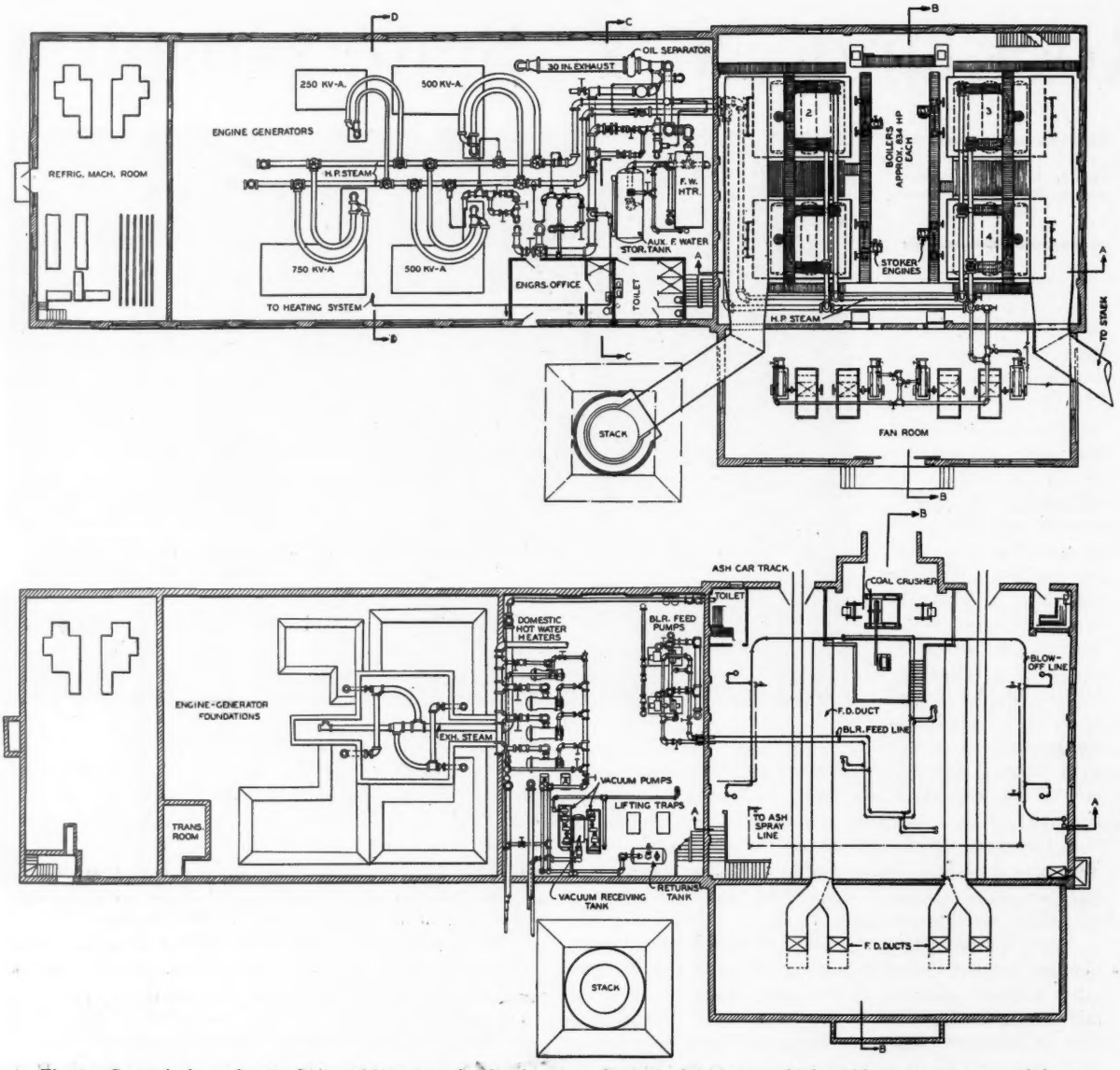


Fig. 3. General plans of main floor and basement showing location of principal equipment, high and low pressure steam piping

metering type, giving a continuous record of all water fed to the boilers. Feedwater is supplied by two 3-in., 3-stage turbine pumps driven at 2750 r.p.m. by impulse turbines of 80 hp. each, and each pump will deliver 175,000 lb. of water per hour (5000 hp.). The deep well water supplied is of such good quality that no external feedwater treatment is required.

Steam and Water Distribution System

Distribution of steam and water to all the hospital buildings, including numerous residences of the medical staff and the employes' homes, and the hot water return system is necessarily complex. In addition to the low pressure vacuum heating system, there are two high pressure steam supply systems, one at 80 lb. to the laundry and one at 40 lb. to the several kitchens. Steam for these systems is taken from the main steam header at the power house, through reducing valves.

The vacuum heating system which must provide an unfailing supply of heat to numerous buildings spread over a wide area, receives its supply directly from the exhaust of the main engines and auxiliaries which is supplemented by live steam supplied through two reducing valves on the high pressure mains in the power house, so arranged that steam can be taken from either or both of the duplex mains, as required. Condensate from the entire system is returned to a receiver in the pump room of the power house and from there, delivered by an automatically controlled motor driven condensate-vacuum pump to the feedwater heater.

Continuity of service under all conditions is demanded of the water supply system for both cold and hot water. Water is drawn from a number of deep wells located on the hospital grounds and delivered to a central supply basin for the main circulating pumps, located in the power house, which are three in number and of the single stage volute type. Two of

these have a capacity of 1000 g.p.m., one being driven by a turbine and the other by a slip ring induction motor. The third is also motor driven and is of 500 g.p.m. capacity. Pumps are automatically controlled in normal operation, but may also be manually controlled. The discharge of these pumps delivers water directly into the cold water service system and to two reserve storage tanks having a total capacity of 1,500,000 gal.; the system being so balanced that a practically constant head is maintained with the pumps on or off. The system also delivers water to a set of four closed hot water heaters arranged in parallel, through which a constant supply of hot water at 160 deg. is maintained to the hot water service system of the hospital.

Piping for the distribution system is carried to all parts of the institution through permanent tunnels, of heavy waterproof concrete construction. These tunnels are from 6 to 8 ft. wide by 8 ft. high, are well lighted and ventilated and allow plenty of space for any emergency repair work that must be done. All pipes are carried on frames as shown in Fig. 6 and all lines are covered with 85 per cent magnesia sectional covering, with an exterior waterproof covering of wire wrapped rubberoid roofing felt. The hot water service and condensate return lines are of extra heavy brass pipe with vanstone joints, and the medium pressure steam, both 80 and 40 lb., and the low pressure steam heating lines, are of extra heavy eletrical welded steel pipe, with fittings only at the points where directional

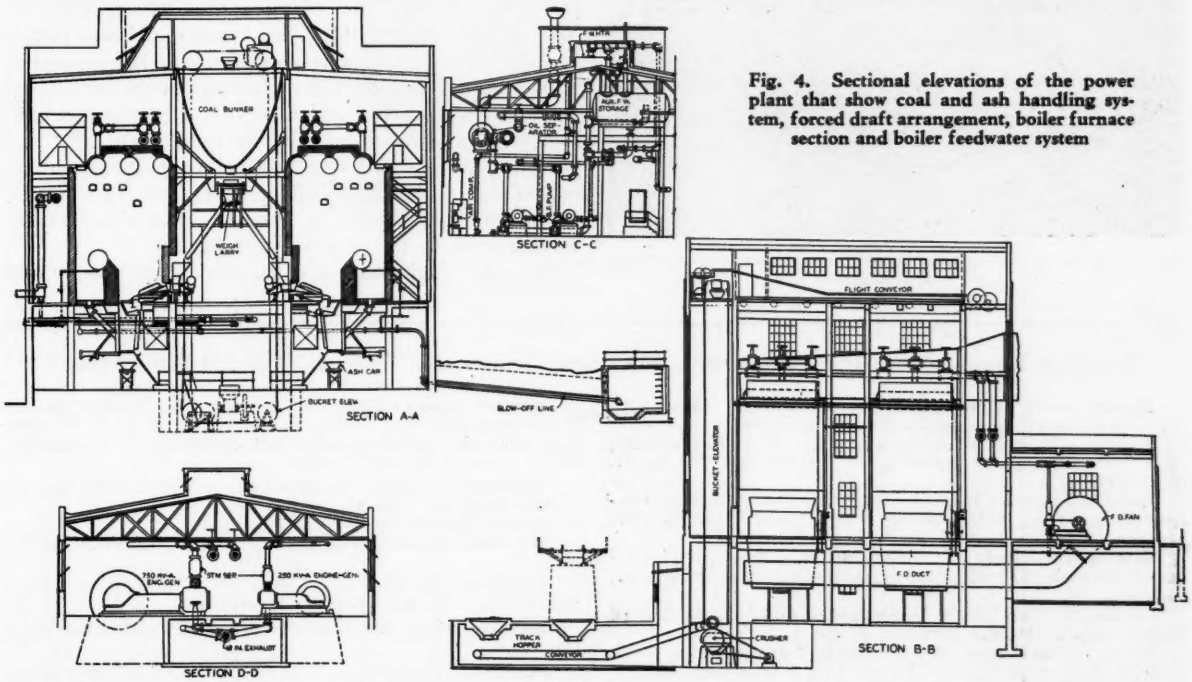


Fig. 4. Sectional elevations of the power plant that show coal and ash handling system, forced draft arrangement, boiler furnace section and boiler feedwater system

Fig. 5. The firing aisle gives ample space for all needed repair work and the operation of a weigh larry to distribute coal to the stoker hoppers

Fig. 6. Section of underground steam tunnels showing arrangement of piping

all the institution buildings can be reached from the power house in a few minutes without leaving the tunnels, so the efficiency and accessibility of the system is unaffected by weather conditions.

Electric Distribution

The switchboard was designed to combine simplicity and accessibility. In addition to the four main generator panels, the four exciter panels and the original voltage regulator panel, there are now panels for the new motor driven exciter and its regulator. There are nine separate distribution panels, each fitted with two oil switches which serve the groups of buildings, pumps and ice machine stations with light and power. Distribution is at 2300 v., wires being run in permanent underground fiber and concrete conduit, with manholes located at junction points and transformer stations for easy accessibility.

As the institution has its own sewerage system and is located some distance from any river or other natural disposal point, some provision for local disposal was a necessity. The Imhoff disposal system installed has been operated continuously with entire success and is of ample capacity to care for any con-

Principal Equipment in the Orangeburg, Rockland County, N. Y., State Hospital Power Plant

Boilers—Four, Union Iron Works, 4-drum water tube type, each having 8350 sq. ft. of heating space.

Stokers—Combustion Engineering Co. Frederick stokers, each with 100 sq. ft. active grate surface and 120 sq. ft. total surface.

Engines—Four, Elliott Co., Ridgway, non-releasing Corliss 4-valve type, with electric remote control inertia governors.

Generators—Elliott Co., revolving field type direct connected, 3-phase, 60-cycle, 2400-v., with direct connected 125-v. exciters.

Chimneys—Two, M. W. Kellogg Co. radial brick, 210 ft. high by 10 ft. internal diameter at top.

Boiler Feed Pumps—Two, Frederick Iron Works, 3-in., 3-stage direct connected to Murray Iron Works turbines.

Forced Draft Fans—Four, Green Fuel Economizer Co., steel plate fans direct connected to horizontal engines of the Troy Engine and Machine Co.

Feedwater Heater—Cochrane Corp., V-notch metering type for 10 lb. pressure with capacity of 175,000 lb. of water per hour.

Feedwater Treatment—Dearborn Chemical Co.

Hot Water Service Heaters—Four, American Locomotive Co., closed type, "Alco" heaters.

Coal Handling Equipment—C. W. Hunt Co., apron feeder, bucket elevator and flight conveyor with Jeffrey Mfg. Co. crusher; capacity 60 tons of coal per hour.

Hydraulic Ash Gates—Allen-Sherman-Hoff Co.

Water Service Pumps—Frederick Iron Works, single stage pumps, two direct connected to Northwestern wound rotor type motors, one American Well Works pump direct connected to Elliott Co. turbine.

Vacuum Pump—Nash Engineering Co., duplex vacuum pump connected to a 20 hp. General Electric motor through Falk reduction gear, motor direct connected to a Jennings single stage condensate pump.

Atmospheric Relief Valves—Two, Kieley & Mueller, Inc.

Oil Separator—Wright-Austin Co.

Steam Separators—Wright-Austin Co.

Switchboard—General Electric Co. and Condit Electrical Mfg. Co.

Transformers—General Electric Co., Westinghouse Electric & Mfg. Co. and Kuhlman Electric Co.

Blowoff Valves—Ohio Injector Co. and Everlasting Valve Co.

Feedwater Regulators—Swartwout Co., "S-C" Regulator.

Boiler Meters—Bailey Meter Co.

CO_2 Recorder—The Hayes Corp.

Soot Blowers—Diamond Power Specialty Corp.

Water Meters—Cochrane Corp., V-notch and Worthington Pump & Machinery Corp. cold water meters.

Lubricators—S. F. Bowser Co. and Manzel Brothers Co.

Pipe—Grinnell Co.

Pipe Covering—Keasbey & Mattison Co.

Reducing Valves—Kieley & Mueller, Inc.

Stop and Check Valves—Reading-Pratt and Cady Co.

Deep Well Pumps—American Well Works.

Refrigerating Machinery—York Ice Machinery Co.

Steam Traps—Tilt traps, Bundy Steam Trap Co., bucket traps, Wright-Austin Co. and Armstrong Machine Works.

General Contractor—Almirall & Co.

Electrical Contractor—Industrial Electric Co.

changes are made. No expansion joints or loops are used, expansion being taken care of at the above points by the cold drawing system.

It will be seen from the above that every point in this extensive distribution system which connects with

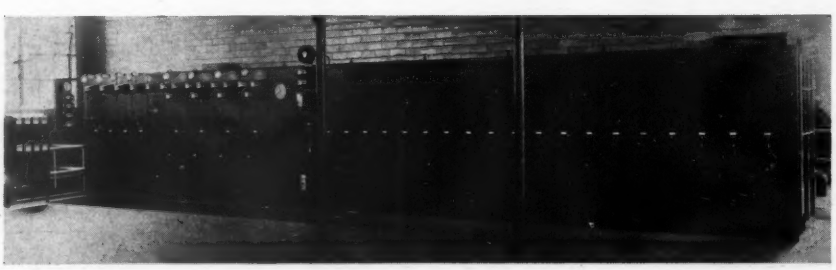


Fig. 7. All electric power generation and distribution is controlled at this main switchboard

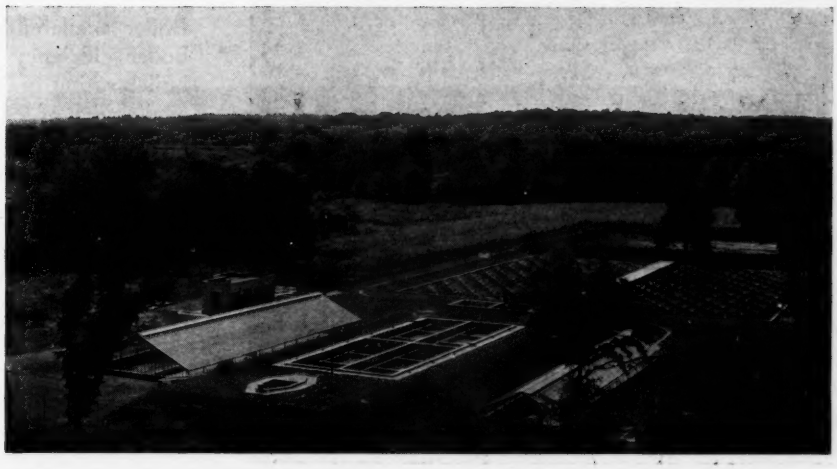


Fig. 8. This view of the sewage disposal plant, 5 mi. from the Hudson River, indicates the peaceful surroundings provided for the psychopathic patients

templated increase in size of the institution. The dried sludge is used as fertilizer by farms in the vicinity and the effluent is chlorinated and then pumped to the nearest small stream of running water, which delivers it to the Hudson River which is about 5 mi. away.

Telephone System

The description of this plant would not be complete without a few words on the automatic telephone system installed by the New York Telephone Co.

This is a 701-A system, the first of this type to be installed in an institution of this kind. It was originally arranged for a capacity of 300 extension lines, which can be increased to 600, and is entirely automatic in operation, and all extensions are equipped for dial operation. In addition to this, a one position manual board is provided to take care of incoming long distance and emergency calls.

Compressed Air Requirements for Hammers

How the Woodings-Verona Tool Works of Verona, Pa., saved approximately $8000 a year by replacing steam with compressed air on their hammers was told recently in an article by R. C. Grimstad and F. A. Kolb of Duquesne Light Co. in Byllesby Management. The change involved seven hammers with a total falling weight of 16,700 lb. and required the installation of a 350-hp. synchronous motor driven compressor. The complete cost was about $17,000.

Air requirements for the hammers were calculated from the chart shown. The load factor referred to is the ratio of working time of the hammer to the total time the hammer is under pressure and can be determined by actual timing with a stop watch.

Sufficient compressor capacity was installed to operate two 4600 lb. and one 1500 lb. hammer at the same time. From the curve this would require 134,000 cu. ft. per hr., or 2233 cu. ft. per min. Some allowance was made for the diversity factor and receiver capacity and a compressor of 1808 c.f.m. was installed. This has been able to successfully meet the operating conditions.

Previous to the installation, load conditions were estimated at 253 kw. maximum demand with 15 minute peaks, and a monthly consumption of 46,192 kw-hr. Actual measurements since the installation was put in

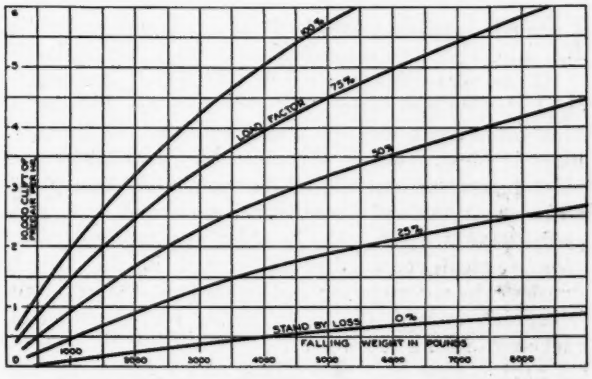


Chart showing air requirements of hammer operating under various load factors

shows 280 kw. maximum demand and 33,775 kw-hr. per month. The savings was divided about as follows: Repairs and water each $1700; labor $3400; coal cost minus power cost and fixed charges at 14 per cent $1200.

Famous Engine Displayed

An accurate scale model, built by George H. Corliss, of the Corliss steam engine which furnished all of the power for Machinery Hall during the Centennial Exposition in Philadelphia in 1876 has been placed on exhibition at the Museum of Science and Industry in Chicago.

The original of this engine had a fly-wheel 30 ft. in diam. and a cylinder bore and stroke 40 in. by 10 ft. A shaft 352 ft. long was used with the engine and from this shaft all of the power needed to run the machines in Machinery Hall was taken. After the exposition the engine was purchased by the Pullman Co. and ran its Chicago shops until 1910. It was dismantled and sold for junk in 1914.

Boiler availability of 96 and 98 per cent; boiler efficiency of 86 per cent; average boiler rating of 209 per cent; and turbine availability of 99 per cent reflect operating reliability of municipal plant with average generating cost of 5.27 mills per kw-hr.

By JAS. D. DONOVAN

Manager of Production and Distribution,
Board of Public Utilities,
Kansas City, Kansas

Municipal Plant Has Splendid Record

IN THE EARLY PART of 1932, the Board of Public Utilities of the city of Kansas City, Kan., placed in commercial operation a new addition to the municipal electric generating station which has effected a substantial reduction in operating costs. This new plant is constructed on the same site occupied by the older generating station and the municipal water plant on the west bank of the Missouri River and it is operated in conjunction with the older generating station, the electrical controls being located in the switch house of the older station and steam from the new unit being delivered to the older station for operation of turbo-generating units.

At the time this new plant was constructed the older generating station, which was started in 1912, comprised some 16 water tube boilers ranging from 300 to 600 hp. each and five electric turbo-generator units ranging from 2500 to 10,000 kw. each, the total connected generating capacity being 29,000 kw. Steam conditions in the older station are 175 lb. ga. 100 deg. F. superheat and generator characteristics are 3 phase, 60 cycle, 2300 v.

New Plant

As originally completed in the early part of 1932 this new plant* contained one steam generating unit and one turbo-generating unit together with a full complement of auxiliary equipment but an additional steam generating unit was installed and placed in service in June of 1933. The steam characteristics of the new station are 400 lb. ga. 700 deg. F. total temperature and electric generation is at 13,800 v. Steam from the new station is transmitted to the older generating station through pressure regulating valves and desuperheater equipment capable of handling a maximum of 300,000 lb. per hr.

In regular operation the turbo-generator in the new plant is base loaded at practically full load, all of the excess over this unit's capacity being taken up by generating units in the old station. A sufficient number of boilers in the old boiler room are maintained under bank ready to supplement either of the new steam generating units when out of service for inspection or other causes and one of the boilers in the old boiler plant is maintained continuously on the line for the purpose of maintaining headers hot at all times and serving as a makeup unit for condensate losses. The steam generating units in the new plant use pulverized coal as fuel and are fitted with slag tap type of furnace. This is the first installation of this type of equipment in this locality using Southern Kansas screenings as fuel and its operation has been followed with considerable interest by the engineering fraternity.

These steam generators are Babcock & Wilcox Stirling units equipped with a full Bailey water wall furnace and water cooled slag tap furnace bottom. Each boiler contains 16,267 sq. ft. of heating surface, has a normal rating of 150,000 lbs. of steam per hour and a four-hour rating of 180,000 lbs. of steam per hour. Each boiler is complete with superheater, economizer, and air preheater. Ash removal from the furnace is by means of tapping spouts where the slag falls into disintegrating chambers and is pumped by motor driven pumps to an overhead storage hopper ready for loading into railway cars.

With each steam generator there are two B. & W. table type pulverizing mills identified as each having a capacity of approximately 13,000 lb. of coal per hour. It has been the practice in regular operation to use one mill at a time and it is possible to support an evaporation of approximately 125,000 lb. of steam per hour with a single mill.

Fuel used in this station is from the southeastern district of Kansas referred to as Southern Kansas bituminous screenings and contains on an average

*See 100,000-kw. Kansas City Municipal Plant, by R. L. Baldwin, Power Plant Engineering, p. 478, June 15, 1932.

11,800 B.t.u. as fired, 15 per cent ash, 7 per cent moisture, and approximately 3.5 per cent sulphur. When the plant was first placed in operation some minor difficulties were encountered in handling the slag resulting from this fuel. The principal trouble developed as a result of the rather large amount of sulphide present in the ash which had the effect of washing out slag spout liners and causing some other disturbances, but these difficulties were of a somewhat minor nature and were overcome in a short time by the use of water cooled spout liners and some small modifications in the arrangement of the spout entrances to the furnace. The ash produced by this type of fuel has a very low fusing point, in fact flows very readily at approximately 2,000 deg. F. and this of course makes it particularly applicable to this type of furnace.

The manner in which these steam generating units have functioned is indicated by the following service record for the year 1934:

	Boiler No. 17		Boiler No. 18	
Hours available	8,385	95.72%	8,597.30	98.14%
Hours not available	375	4.28%	162.30	1.86%

OUTAGE RECORD

BOILER No. 17

3-10-34	Inspection	196 hr.
9- 9-34	Welding soot blower	2 hr.
10-29-34	Hand hole gaskets	2 hr.
11-20-34	Inspection	175 hr.

BOILER No. 18

3- 3-34	Inspection	77 hr.
3-24-34	Repair soot blower	2 hr.
9-23-34	Repair soot blower	2 hr.
11-13-34	Inspection	77 hr. 30 min.
12- 1-34	Soot blower valve	2 hr.
12- 6-34	Soot blower valve	2 hr.

OPERATING EFFICIENCY

	Boiler No. 17	Boiler No. 18
Actual evaporation, lb.	776,285,588	770,967,618
Average per hour, lb.	102,265	101,947
Per cent of rating	209.64	208.99
Total coal, tons	42,092.25	41,817.75
Average B.t.u. as received, per lb.	11,824	11,824
Average boiler efficiency, %	85.54	85.86

	Mill No. 1	Mill No. 2	Mill No. 3	Mill No. 4
Total tons of coal	22,249.2	19,843.05	21,792.75	20,025
Average tons per hour	5.55	4.83	5.4	4.83
Tons of coal per change of balls	19,831.65	20,356.95	20,406.45	19,607.35
Tons of coal per change of grinding elements	26,502.5	28,895.75	26,641.25	No change

A change is based on the complete wearing out of one set of lower balls which are 9 in number, 9.25 in. in diameter, weighing approximately 120 lb. each. The upper grinding element has 8 similar balls.

The turbo generating unit installed in this new station is a Westinghouse unit rated 12,500 kv-a., 13,800 v., operating at 3600 r.p.m. with a direct connected exciter. The turbine is served with an Elliott surface condenser having 15,000 sq. ft. of surface in 1 in., 18 B.W.G. Admiralty Metal tubing and is equipped with steam jet air ejectors. The turbine of this unit is a bleeder type with four stages of bleeding. The No. 1 stage is not used in present operation but the other three stages are used for evaporator, deaerators, and feed water heating. The record of operation for this turbine and condenser for the year 1934 is as follows:

Total hours run	8,741.55
Total generation, kw-hr.	83,964,000
Average generation per hour run, kw.	9,605
Availability, %	99+

While there have been some minor difficulties with various pieces of auxiliary equipment installed in this new station, generally speaking the auxiliary equipment, including all heat balance apparatus and automatic control features, has functioned well and has an availability service record equal to that of the main steam and electric generating units.

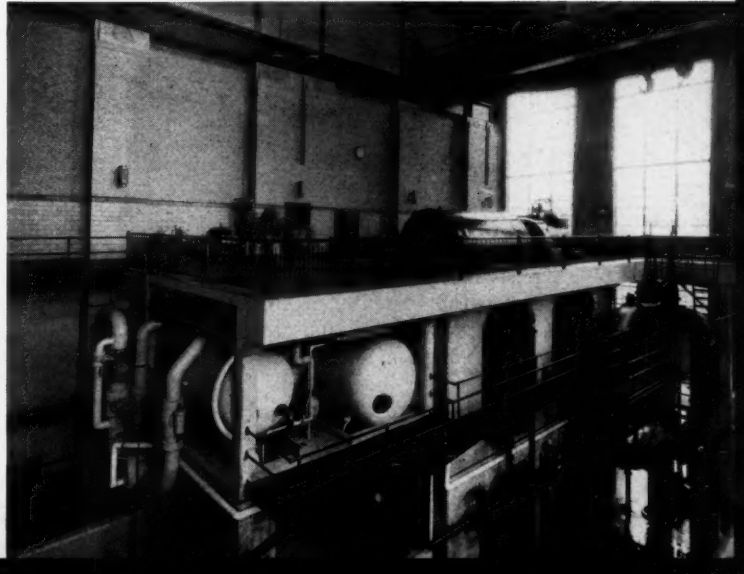
As stated before, this new station is operated in conjunction with the older generator station and consequently it is not possible to accumulate the individual station efficiencies because of the exchange of steam taking place between the two plants. However, the two plants have been separated on several occasions for test purposes and it has been ascertained that it is possible, when operating the new station only, to produce a kilowatt hour on slightly less than 14,000 B.t.u. In operating the old station prior to the construction of the new one the best performance it was possible to maintain was approximately 29,680 B.t.u. per kw. hr. In operating both stations jointly, as was the case during the year 1934, a kilowatt hour was produced for 21,240 B.t.u.

During the year 1934 the total net kilowatt hour production of both plants was 120,909,429. Hence the increased efficiency obtained from the combined operation of the new and old station produced a saving on the 1934 production of some 48,363.77 t. of coal or $123,327.61 at the prevailing delivered cost of fuel.

Detailed figures on switchboard costs for the year 1934 are not yet available but the costs for the month of December are typical and will approximate the annual figures, and are as follows:

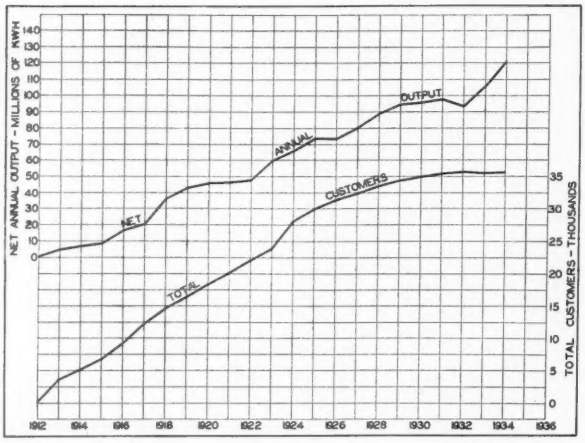
	Total	Per Unit
Wages—Operation	$18,781.47	$0.00181
Fuel	24,872.90	0.00240
Water consumed	2,395.29	0.00023
Less Steam Sold to Water Dept.	501.60	0.00005
Lubrication	84.04	0.00001
Miscellaneous	1,117.17	0.00011
Maintenance	7,870.79	0.00076
Total	$54,620.06	$0.00527

Before commencing the construction of this new station the consulting engineers of the Board developed a general plan for a future station that will have when completed a total connected generating capacity of 100,000 kw. hr. and it will be the Board's policy to continue the operation of the older generating station until such time as it can be supplanted by future additions to the new generating station. It has further been the established policy of the Board to finance all additions and betterments from plant income rather than from bond issues and there have been no bonds issued or sold for additions and betterments to the electric plant and distribution system since 1925. This new addition to the generating station including the

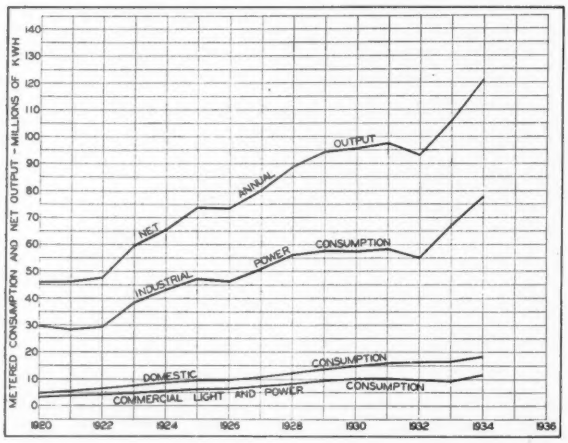


The turbine room at the Kansas City municipal plant

additional steam generating unit purchased and installed in 1933 represented a total expenditure of approximately $2,000,000 and it was paid for entirely from the revenues of the Electric Light Department without the issuance of any bonds.



Curves showing the growth of the system

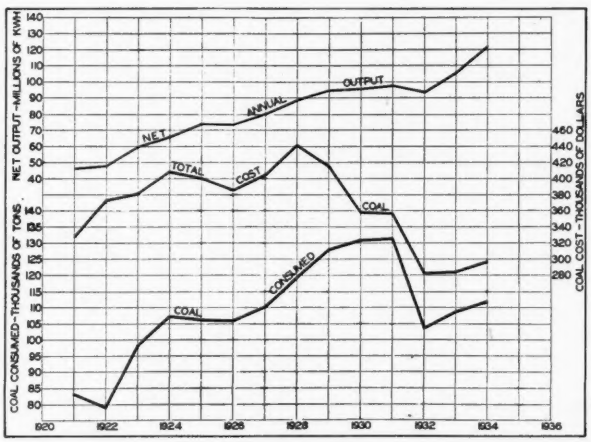


As was stated in the case of switchboard costs, the detailed cost figures for the year 1934 for both production and distribution are not yet available but the December costs which are typical of the year for the total cost of production and distribution including all divisions of the Electric Light Department were as follows:

	Total	Per Unit
Fuel	$24,872.90	$0.00240
Water consumed	2,395.29	0.00023
Less Steam Sold to Water Dept.	501.60	0.00005
Lubrication	84.04	0.00001
Wages—Operation	37,729.20	0.00364
Maintenance	14,488.94	0.00140
Depreciation	34,311.69	0.00331
Interest and Commission on Bonds	8,988.64	0.00087
Interest on Guarantee Deposits—Consumers	234.25	0.00002
Allowance for Bad Debts	987.91	0.00009
Miscellaneous	9,739.76	0.00094
Totals	$133,331.02	$0.01286

Kansas City, Kan., is an industrial community in which are located many large manufacturing institutions such as packing houses, flour mills, grain elevators, oil refineries, railroads, soap plants, and numerous other types of industry all of whom depend on the municipal water and light plants for these respective commodities. This condition brings about a rather unusual situation in so far as plant loads are concerned, at least to the extent that the peak loads and maximum production of the electric plant occurs during the summer period, usually the month of August, rather than in December as is usually the case in central stations. This situation is brought about primarily through the fact that the packing industry uses substantial quantities of electric energy for refrigeration purposes and consequently the warm period of the year increases their total demand and usage so as to bring the plant peak loads in the summer rather than in the winter months.

The municipal plant serves the light and power requirements of some 35,574 customers and the water requirements of some 28,375 customers. During the year 1934 light and power sales to industrial users represented a total of 77,844,663 kw. hr. which produced an income of $752,726.39 or an average return of $0.0097 per kw-hr. During this same period the sales of electric light and power to commercial users totaled



10,180,271 kw-hr. which produced an income of $364,512.10 or an average return of $0.0358 per kw-hr. Residential consumers during this period consumed 18,429,435 kw-hr. which produced an income of $622,938.05 or an average return of $0.0338 per kw-hr. Of the 18,429,435 kw-hr. sold to residential customers 6,082,049 kw-hr. was at a 6 cent rate, 93,982 kw-hr. at a 3 cent rate, 11,177,813 kw-hr. at a 2 cent rate, 857,747 kw-hr. at a 1½ cent rate and 217,844 kw-hr. used by minimum use customers brought a return of 8.61 cents per kw-hr.

In exchange of services between the Water Department and the Light Department the Electric Light Department pays the Water Department for water consumed on the basis of standard rate schedules and the Water Department pays to the Electric Department for energy used for high pressure water pumping at the station a flat rate of 7 mills per kw-hr. and for electric energy consumed in small booster pumping stations at different locations in the city a flat rate of 9 mills per kw-hr.

Both the water and electric plants are under the supervision of a Board of Public Utilities consisting of five men elected by the people at large and serving at a salary of $100 per year.

Interconnection of Electric Power Systems

Under private ownership, electric utilities have built up extensive, high-potential, interconnected systems on an economic basis; interest now centers in government plans to supply power

RECENT FEDERAL ACTIVITY has revived the question of interconnection of power plants by transmission and distribution lines in order that the advantages of interchange of power may be available to generating and using plants. The economics of this practice has been a subject of discussion from the time electric power was first transmitted from one town to another. From an engineering standpoint, many problems involved in the interconnection of power plants have been solved so that in the last analysis, interconnection is a problem in economics and it is to this phase of the situation that Government authorities, privately and publicly owned utility interests, industrial plant owners and the general public must give their attention and come to a substantial agreement if a satisfactory solution is to be the outcome.

Interconnection of power plants, grid systems, power pools, interchange of power and giant power are terms that are very closely synonymous so far as the engineering problems are concerned. In every case it means supplying power to or taking it from a distribution or transmission system. Throughout the entire history of the electric utility industry, the process of interconnection has been extending, at times slowly, at others rapidly, depending upon the extent of agreement that could be reached between the persons concerned with the proposed interchange. Up to the present time, in the United States, the interconnection of power plants and the interchange of power has been substantially of a voluntary nature with but few exceptions where political authority has been exerted, and in most such cases interconnection has been prevented rather than compelled.

Presentation of Fact Needed

Just how far the present national administration intends to go toward encouraging or compelling interchange of power is not known at this time. It is quite possible that the proposals made thus far have been given publicity for the purpose of finding the public opinion on the subject, with a view toward shaping satisfactory legislation. At any rate, a discussion of the subject at this time, before definite legislation affecting the entire country has been enacted, is needed to place facts before those with authority to act in legislative affairs. Facts, relative to the extent that industry has already gone in the direction of establishing a common network of electric lines; facts pertaining to agreements between power companies contributing to the network; facts dealing with the amounts of power interchanged between systems; facts regarding the direction of current flow and the amount at different periods of the day, week and year; facts covering reliability of different kinds and sizes of plants feeding into the system, whether they are steam or hydraulic, utility or industrial, privately or publicly owned; in fact every phase of the problem that bares on the economics of such a system needs to be brought out, correlated, tabulated, analyzed and presented as guiding information to the law making bodies of the country.

In principle, interconnection of power systems has for its main objectives the following results:

Service to all communities where electricity can be used.

An uninterrupted supply of electricity to all sections of the combined system.

Utilization of power available from hydraulic sources.

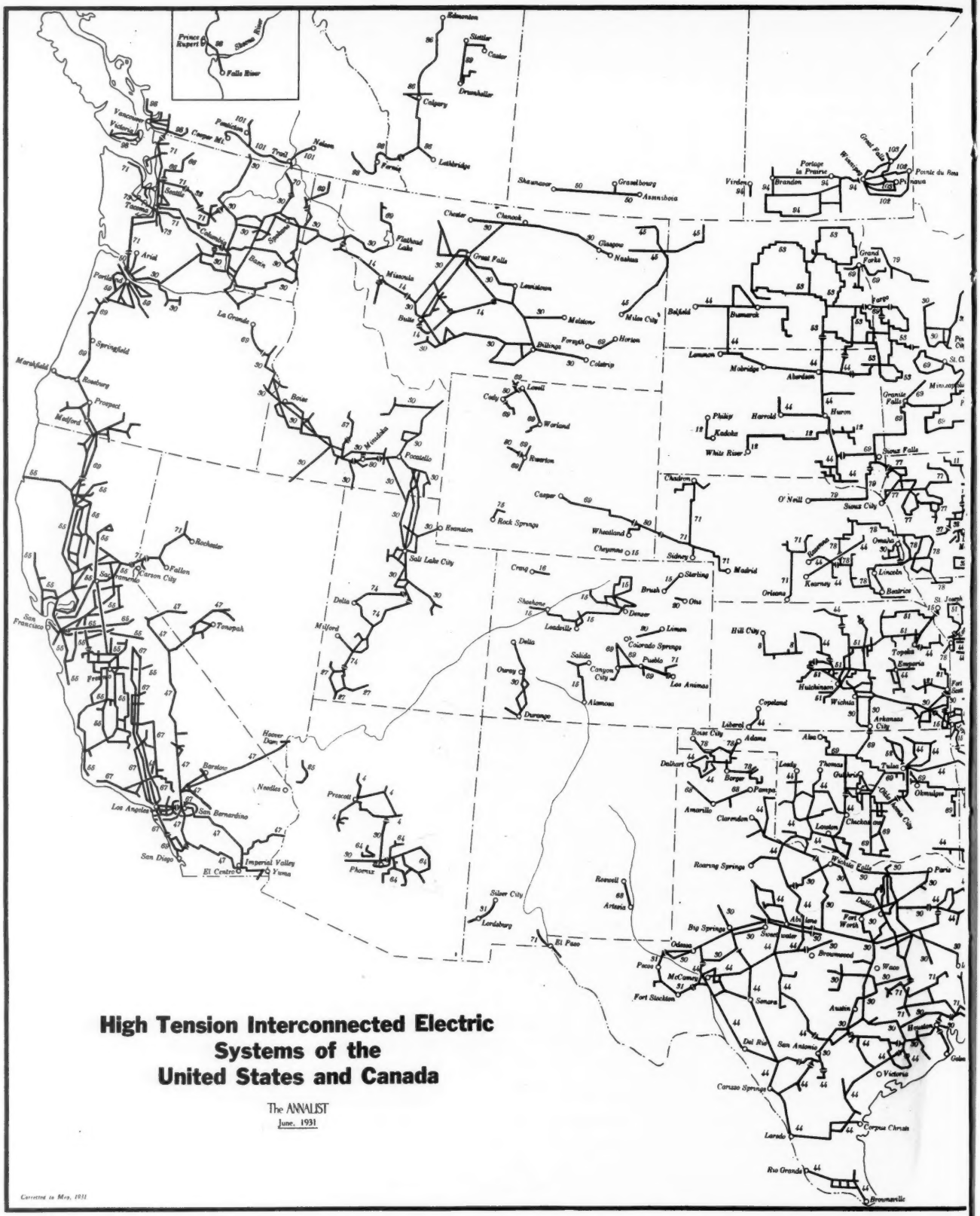
Most efficient use of natural fuels in the generation of power.

Mutual financial benefit to owners of interconnected systems and users of power.

Electric Power Wherever Needed

Generation of electric power has reached that stage of the art where equipment is commercially available that will enable the isolated home owner to operate his own plant at a cost that is within the reach of any prosperous farmer. At cross road home groups, hamlets and villages some saving in expense and relief from care of the plant may be gained to the householder by a community plant, either owned by the group of householders served who share alike in the expense or by a private concern which charges customers according to a rate which permits operation of the plant, usually part time, at a profit to the owner. Coming to the larger villages and small cities, little difference in the service is noted except that the plants are larger, hours of service are extended to 24 hr. of the day, instead of part time as in many localities, and the rates are modified to meet the demands of the local customers according to their power requirements and the type of service required as well as their proximity to the generating plant.

With increasing population and industrial loads, the problem of plant location becomes serious and may even be the determining factor between profit and loss in the operation of the plant under the rate conditions to which the utility is subjected. In metro-



High Tension Interconnected Electric Systems of the United States and Canada

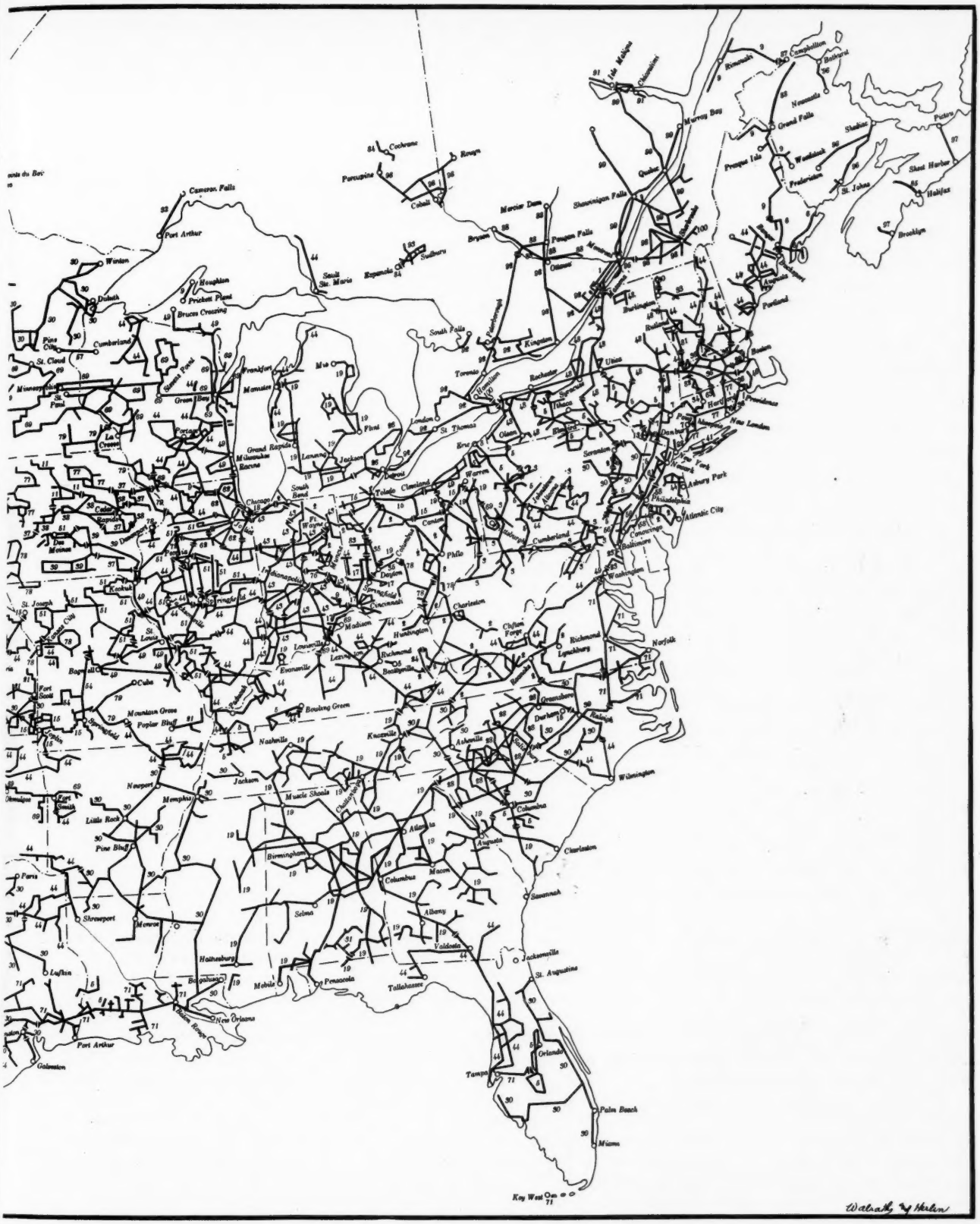
The ANNALIST

June, 1931

Corrected to May, 1931

KEY

1. Aluminum Company of America
2. American Gas & Electric Co.
3. American Water Works & Elec. Co.
4. Arizona Power Co.
5. Associated Gas & Electric Co.
6. Bangor Hydroelectric Co.
7. Central Hudson Gas & Electric Co.
8. Central Kansas Power Co.
9. Central Public Service Corporation
10. Central States Edison Co.
11. Central States Electric Co.
12. Central West Public Service Co.
13. Charles H. Tenney & Co.
14. Chicago, Milwaukee, St. Paul & Pacific Railroad
15. Cities Service Co.
16. Colorado Utilities Corporation
17. Columbia Gas & Electric Co.
18. Commonwealth Edison Co.
19. Commonwealth & Southern Power Corporation
20. Commonwealth Utilities Corporation
21. Community Power & Light Co.
22. Consolidated Gas Co. of N. Y
23. Consolidated Gas, Electric Light & Power Co. of Baltimore
24. Consolidation Coal Co.
25. Desert Power & Water Co.
26. Detroit Edison Co.
27. Dixie Power Co.
28. Duke Power Co.
29. Edison Electric Illuminating Co
30. Electric Bond & Share Co.
31. General Water Works & Elec. Corp.
32. Great Northern Railway
33. Green Mountain Power Corporation
34. Hartford Electric Light Co.
35. Indiana, Columbus & Eastern Traction Co.
36. International Paper & Power Co.
37. Iowa Electric Co
38. Iowa Railway & Light Corporation
39. Iowa Southern Utilities Corporation
41. Long Island Lighting Co.
42. Los Angeles Bureau of Power & Light
43. Midland United Co.
44. Middle West Utilities Co.
45. Montana-Dakota Power Co
46. Montaup Electric Co.
47. Nevada-California Electric Corp
48. Niagara-Hudson Power Corporation
49. North American Co.
50. North American Gas & Elec. Co.
51. North American Light & Power Co.
52. Oklahoma Power & Water Co.
53. Otter Tail Power Co.
54. Ozark Utilities Co.



55. Pacific Gas & Electric Co
56. Pennsylvania Water & Power Co.
57. Peoples Light & Power Corp
58. Philadelphia Electric Co.
59. Portland Electric Power Co.
60. Public Electric Light Co.
61. Public Service Corp. of New Jersey
62. Public Service Company of Northern Illinois
63. Rockville-Willimantic Lighting Co.
64. Salt River Water Users Association
65. San Francisco Municipal Plant
66. Seattle Municipal Plant
67. Southern California Edison Co
68. Southwestern Public Service Co
69. Standard Gas & Electric Co
70. Stevens County Power & Light Co.
71. Stone & Webster, Inc
72. Super-Power Company of Illinois
73. Tacoma Municipal Electric Plant
74. Telluride Power Co.
75. Union Pacific Coal Co
76. Union Traction Co.
77. United Gas Improvement Co.
78. United Light & Power Co.
79. Utilities Power & Light Corporation
80. U. S. Reclamation Service
81. Vermont Marble Co.
82. Western Massachusetts Companies
83. Western Ohio Railway Co.

CANADA.

84. Abitibi Power & Paper Co., Ltd.
85. Avon River Power Co.
86. Calgary Power Co., Ltd.
87. Campbellton, Municipality of
88. Canadian Hydroelectric Corp., Ltd.
89. Canadian Utilities, Ltd.
90. Dominion Power & Transmission Co., Ltd.
91. Duke-Price Power Co., Ltd.
92. Hydroelectric Power Commission of Ontario
93. International Nickel Co. of Canada, Ltd.
94. Manitoba Power Commission
95. Montreal Light, Heat & Power Consolidated
96. New Brunswick Electric Power Commission
97. Nova Scotia Power Commission
98. Power Corporation of Canada
99. Shawinigan Water & Power Co.
100. Sherbrooke, Corporation of
101. West Kootenay Power & Light Co.
102. Winnipeg, City of
103. Winnipeg Electric Co.

Source of data. The Analyst, The New York Times Publishing Co., New York

politan areas, therefore, several generating plants are usually built, located in the most advantageous places available as regards load center, condensing water, fuel transportation, real estate values and the effect on public relations of the neighborhood. These utility plants are invariably connected together electrically through a network or transmission and distribution lines. Except in comparatively few cases, only one company is given the right to the use of streets and alleys for distribution lines in the service of customers within the corporate limits of a city. While this custom has many decided advantages, it has one disadvantage, so far as customers are concerned, in that the electric utility becomes a monopoly without a competing company to force changes in rates and service, and this is the principal cause of controversies between utilities and the political authorities.

With more than one plant serving a distribution system several advantages may accrue, principal among which are that distribution losses should be reduced and reliability of service increased.

As high potential transmission lines became practicable, the possibilities of generating power at hydraulic sites considerably remote from industrial centers and in steam plants at the mine mouth where condensing water was available were studied and many plants have been built for this type of service. Considerable difference of opinion exists among engineers as to how far a company is economically justified in going toward developing power at sites remote from a power market. These questions, however, are case problems to be solved at the time each site is brought up for consideration; for changes in population centers and industrial developments, together with advances being made in the art of power generation and transmission are continuously bringing about economic transitions in power generation possibilities.

Private Interests Developed System

Up to the present time private interests have been largely responsible for the development of power sites in the United States and, with this development, utility companies have recognized the advantages of high potential connections between important industrial centers and power sites where the abundance of hydraulic power or fuel enabled the production of power at a cost which represented a saving. Among the obstacles encountered was the difficulty of securing a market for power from a distance in a city where a franchise was held by another company. This obstacle which delayed many developments has been overcome to some extent by the combining of interests into large controlling corporations. Interconnection of many distributing systems by high potential lines was thus made possible. These lines passing through or close to smaller cities have made it economically feasible for the larger companies to purchase the plants serving the small communities, sometimes at a high premium, at the same time offering a much improved service, often at a lower rate. Along these high potential lines, in many instances have grown up service lines to rural customers in districts where satisfactory agreements could be made.

This, in a few words, summarizes the course of the

Interconnection points between systems operating at voltages above 30,000

development of our present electric utility system. Back of it all has been an economic reason for every step taken. Many mistakes have been made, thousands of individuals have invested in utility stocks and bonds, holding companies have been organized to pyramid securities and there are financial interests that have profited immensely by the course of events, but with it all has come a system of electric service throughout the country that includes almost every hamlet and a network of interconnections which almost precludes the possibility of failure of service to any large city in the country. And a continuously decreasing rate for electric service has been put into effect.

Of recent years a more complicated system of interchange of power has been developed in certain localities where agreements could be reached between the contracting parties. This is commonly known as the power pool or, as in Great Britain, the grid system, which is energized by power from plants of all types located within the district. Thus not only utility plants but industrial plants are connected into the system and supply power under certain conditions of load when they have dump power available, or take current from the line at periods when the cost of generation is greater than the cost of current from the system. This type of interconnection has not been extensively developed in this country, although a number of interconnection agreements have been successfully carried out between utility and industrial plants whose load conditions made such agreements mutually advantageous.

Power Pool Meets Opposition

So many conflicting conditions exist in the operation of power and heating plants that the power pool idea as a general policy has met with strong opposition particularly from the utility interests, who rarely find an industrial plant with dump power available at the time it is needed and with which a satisfactory agreement can be made. Although this system offers some possibilities for the saving of fuel, load curves are difficult to harmonize and it is doubtful that such an arrangement will be greatly extended unless some form of political regulation and control is put into operation to compel power plants to serve the system at a compensation fixed by the regulating authority. Load dispatching under such an arrangement would become extremely complicated and would make necessary public control not only of the distribution system but, to a large extent, the operation of every power plant, whether utility or industrial which is connected to the system.

As has been stated, private industry has been responsible for nearly all of the development of electric systems in the country. The extent of the transmission network and the points of interconnections existing between systems operated by different companies is well shown by the accompanying maps.

Are the industry and those serviced by it ready to turn control of transmission and distribution lines over to commissions chosen by the political powers of the country, knowing that such control means, in the case of a power pool, practical supervision of the program of operation of every power plant feeding into the system whether it be utility or industrial? Or should the country depend, as in the past, upon private industry to supply electric needs at its own financial risk, under perhaps a more rigid rate control system than we have today? The ramifications of the problem do not stop here by any means and the pages of Power Plant Engineering are open to a presentation of facts and authoritative opinions on this problem.

Engineers Discuss Hydro and Fuel Power Plants

UNDER the joint sponsorship of several engineering societies, a public meeting was held on January 31 in Chicago for the purpose of discussing the comparative economic values of hydraulic and steam power plants. Frank D. Chase was the chairman and called upon Frank R. Innes, who was largely responsible for the program, to present the question for discussion. "At the present time," he stated, "when local, state and national governments are rushing into all kinds of projects, the need is imperative for the engineer who will build these projects to develop a professional conscience, to think, to act and to speak as more than just a hired man.

"Right now the government is selling us an awful lot of water power. Are these projects worthy? We can consider here the point that water power may or may not be the best way to supply the tremendously increased amount of electricity that our political friends say the country needs and must have immediately."

Louis E. Ayres, hydro-electric engineer of Ann Arbor, Mich., presented a carefully prepared paper in which the present practice in hydro-electric engineering was summarized. Among pertinent statements made were that water powers now feasible of development amount in capacity to 55,000,000 kw. with the cost of development ranging from $63 per kw. in the Northwest to as high as $274 per kw. in some cases in the Ohio River region, with production costs ranging from 0.8 to 7.3 mills per kilowatt-hour. Federal financing at 3 per cent, he stated, is now possible which makes economically justifiable considerable new water power development.

Fuel power generating plants were dealt with by Frank S. Clark, of the Stone & Webster Engineering Corp., Boston, who pointed to the vast strides made during the past 12 yr. which have resulted in remarkable increases in thermal efficiencies in steam power plants and the binary vapor cycle. Great advances, he stated, have been made also in the design, capacity and use of internal combustion engines. He cited one instance of a gas fired steam plant, with 100,000-kw. generating units, that operates in conjunction with hydro-electric plants and has shown an economy of 13,125 B.t.u. per kw-hr. at 65 per cent load factor and 14,550 B.t.u. at 16 per cent load factor.

Both authors consider the choice of the type of plant a question of determining the needs of the situation and obtaining the best combination of operating and fixed charges, combined with due regard to reliability of services and the larger business aspects of the situation.

COMBUSTION CONTROL

Part II. Factors Involved in Boiler Control Methods of Regulation and Influence of Operating Practice

COMBUSTION CONTROL is a broad, more-or-less generic expression used in many industries for a variety of fuels and furnaces. Fundamentally the problem and the means of solving it are the same in all cases and to foster industrial coöperation it seems desirable to retain the general expression leaving each industry to define the limits within its own domain. If this is done it is obvious that the expression itself will have a rather narrow meaning within any single industry because it is impossible to separate combustion itself from the purpose for which combustion takes place.

Thus in the boiler plant, combustion is intimately related to, and is regulated in accordance with, the production of steam which demands the coördination of five variables, steam, water, fuel, air and flue gas in accordance with predetermined conditions. If it were not for the desirability of retaining at least the semblance of a uniform vocabulary between the various branches of engineering it might be advantageous for power plant engineers to substitute the more accurate and descriptive expression "boiler control" for "combustion control," the boiler in this case being considered as the complete steam generating unit (and auxiliaries) from the fuel supply to the stack.

General Requirements

Any control system, whether manual or automatic, must consider the pressure, temperature and flow of the different variables in accordance with the steam demand and, preferably, so as to give the best overall economy. Details of the control will depend upon the fuel used, the arrangement of the plant, design of the equipment and the extent of automatic operation. The fundamental control problem is unaltered by these factors, although it is greatly influenced by contemporary power plant practice which in general demands: First, that the steam pressure be maintained constant, or nearly constant, by varying the rate of combustion in accordance with the steam demands; second, that furnace pressure be maintained at, or slightly below, atmospheric pressure. Operating costs add a third requirement namely: the fuel-air ratio must be maintained so as to give the highest overall efficiency consistent with reasonable furnace maintenance.

The above general requirements do not of course consider recent developments such as the Benson variable pressure boiler in which the pressure varies with the turbine load, or, the Velox boiler which operates with a comparatively high positive furnace pressure. These developments are apparently quite practical, American rights to the Benson boiler have recently been purchased by a prominent turbine manufacturer, and will unquestionably influence future practices. Although control under these conditions will be discussed later, neither development has been considered in discussing conventional practice.

Here steam demand is the independent variable. Water, fuel and air must be supplied and the products of combustion taken away in such a manner as to meet this demand in accordance with the three general requirements stated above. The necessary controls may all be automatic and interconnected, all manual and independent, or any combination of automatic or manual between these two extremes. A more detailed discussion of control of the pressure, temperature and flow of the five variables follows.

The Five Variables

1. STEAM. As the primary purpose of the boiler is to make steam, this is the most important of the five variables and is used as the control factor for the rate of combustion either by maintaining the drum or outlet pressure, at C for instance, substantially constant and using a drop in pressure as an indication of the need for more fuel, or by metering the steam flow, for instance by an orifice as at A, and proportioning the combustion rate to this flow.

In practice, it is usual to make a pressure connection at the header, or, receiver, as at B, and use the piping between the drum and this point as an orifice. This pressure drop, D, varies approximately as the square of the flow, W, in accordance with the equation $W = C \sqrt{D}$ or $D = W^2 \div C$, where C is a constant. Locating the pressure control connection at B is desirable because it maintains the header pressure practically constant, which is desirable and of considerable importance where superheaters are used with a considerable pressure loss variation between the drum and header from light to heavy loads and the pressure drop or differential gives an indication of the actual steam flow and facilitates accurate proportioning of the fuel. Combustion is thus regulated in accordance with the steam flow in such a manner as to maintain a nearly constant pressure at the desired point.

In general practice the steam temperature is regulated only by the boiler design and rating. It is desirable of course to have a nearly constant steam temperature over the entire load range and this is accomplished by changing the design or location of the superheater or using a combination of radiant and convec-

tion elements to give the desired characteristics.[1] In high temperature installations temperature regulation is more important in order to obtain the maximum efficiency and at the same time protect the equipment from damage by excessive temperatures. Although superheat control is not common it may be and has been used[2] with different types of desuperheaters under control of an independent thermostatically operated element.

In general, steam flow is the independent variable and the actuating impulse of the entire control system; steam pressure is maintained constant at some given point by the same initial control device; and steam temperature is controlled beyond the regulation provided for in the design characteristic of the superheater.

2. WATER. Water flow must closely parallel steam flow, especially in modern high pressure boilers where the water storage space in the drum is limited. The flow is easily and commonly metered but the feedwater regulator is ordinarily operated from the water level in the drum. The use of an auxiliary control, or excess pressure regulator, to maintain a constant or predetermined pressure differential across the feedwater regulator in order to improve its operation, is common, as is, the use of a pump governor to maintain a sufficient but not excessive pressure in the feed lines by controlling the speed of the feed pump.

These three controls are regularly independent, the pump governor operates to maintain a constant pressure in the feed line, the excess pressure regulator to maintain a constant differential across the feed valve and the feedwater regulator to maintain a constant water level. In some cases, however, the entire feedwater system including the pumps is tied in with the combustion control system.

Feedwater Temperature

Temperature variations in the feed supply are of course reflected in the heat requirements of the boiler. With the feed pumps taking their suction from an open heater this temperature will remain reasonably constant, especially if the plant is provided with a few alternate steam and motor driven pumps for heat balance purposes. Where extracted steam is used, in either open or closed heaters, the final temperature will vary with the extraction pressure. Attempts to maintain a constant feedwater temperature have been made but this is not customary.

Feedwater flow then closely parallels the steam flow under control of an independent regulator; feedwater pressure is maintained by an independent pump governor and excess pressure regulator and feedwater temperature is unregulated beyond the permanent characteristics of the equipment.

3. FUEL. With constant efficiency, the necessary fuel feed will vary directly as the steam flow and in the normal operating range of most boilers this condition is closely approximated. The boiler steaming rate is, however, determined by heat release, of which fuel feed is but one factor so that the output may be maintained by a low fuel rate with good combustion or by a higher feed rate with poor combustion. Thus the air supply is of equal, and in some cases of greater, importance than the feed supply both from the standpoint of heat release and rate of response to a given load change.

The rate of response and the maintenance of proper combustion is also influenced greatly by the type of fuel and method of firing. Thus with gas, oil and the bin system of pulverized fuel response is rapid due to the ease and comparative accuracy with which the fuel can be controlled and metered. This is also true of a heavy stoker fire but for a different reason. Here the immediate rate of firing is of little importance but the

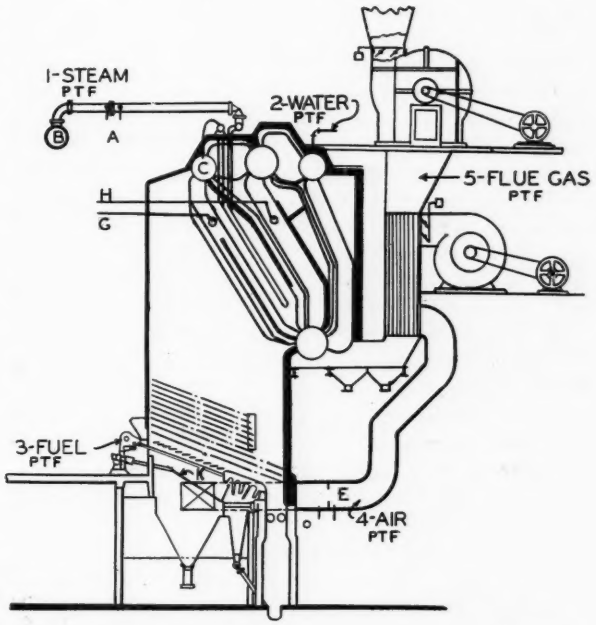


Fig. 1. Typical stoker fired furnace showing the five factors, 1, steam; 2, water; 3, fuel; 4, air, and 5, flue gas involved in control of the boiler. Each of these five have, P, pressure; T, temperature and, F, flow characteristics which must be considered

heat release is easily and quickly controlled through the air supply. With a light stoker fire, or, with the unit system of pulverized coal, the response is relatively slow due to the time required to get the fuel from the feeder device to the furnace.

Maintenance of proper fuel air ratios depend primarily upon the ease and accuracy with which the fuel can be proportioned to the steam flow. Gas and the lighter oils can be metered accurately by the usual type meters; heavy oils quite successfully but with less accuracy; pulverized coal volumetrically by means of feeder sizes and speeds but with still less accuracy; while with stokers the flow can only be approximated by means of stoker speeds. In the case of unit mills the accuracy of measurement of the coal feeder probably lies somewhere between that of pulverized coal and stokers.

The difficulty of coal measurements is further com-

[1] For a discussion of superheater characteristics see Reheat—Practice, Operation and Control, Power Plant Engineering, page 806, December, 1932.

[2] For a description of superheat control see Power Plant Engineering; Reheat—Practice, Operation and Control, page 703, October, 1932; Buzzard Point Plant Supplies Power to Capitol, by H. G. Thielscher, page 478, November, 1933; Colgate-Palmolive-Peet Co., Extends Power Facilities, by Gosta Anbro, page 90, February, 1935.

plicated by the wide variations in physical and chemical properties. Consequently the proper fuel-air ratios can be maintained only by some secondary correction which corrects for the inaccuracies of fuel and air measurement. These corrections are usually based on the CO_2 or steam flow-air flow indications and may be made manually or automatically.

The importance of pressure and temperature control of fuels varies. Coal is ordinarily burned on stokers in the condition it is received without regard to its temperature although it is often tempered by the addition of moisture. With pulverizers, the moisture content is important and is reduced either by separate dryers preceding the pulverizer or by the use of hot air or flue gas in the mill itself. The temperature of the coal leaving a unit mill of this type will be the same as that of the primary air which depends upon the actual moisture content of the coal. The regulation of this temperature is manual.

With oil, on the other hand, both temperature and pressure control are important. To obtain proper burner atomization and combustion the temperature of the oil must be maintained at a definite temperature. This is usually accomplished by steam, the temperature being maintained constant by an independent thermostatic control element regulating the steam flow to the heating coils. Pressure regulation depends upon the system of firing but it is usual to have a pump, governed by an independent pressure regulator, maintain a definite pressure on the fuel oil header. Fuel feed to burners, or, groups of burners, is then controlled by throttling or bypassing by manual or automatic means.

Gas Temperature

With gas the arrangement is somewhat similar except that gas comes to the plant under pressure through an independent reducing valve which operates to maintain a constant pressure in the gas header to the burners. The flow to each burner or group of burners is then regulated by means of a valve under manual or automatic control. Temperature is not controlled but may vary considerably with atmospheric conditions, and, as this temperature variation has a considerable influence on the heat content of the gas per unit volume, the fluctuations are important to the operator.

In general, therefore, the flow of fuel is maintained in proportion to the flow of steam, by varying the pressure at the burner, while the pressure and temperature in a header are controlled by independent regulators or left uncontrolled.

4. AIR. The flow of air is closely related to the flow of fuel and the two should be maintained in a definite but controllable ratio. All types of fuel are adversely affected by large and sudden changes in the air supply, particularly with water cooled furnaces. These disturbances may take the form of smoke, temporary loss of efficiency, bare spots in grates, temporary loss of capacity and possible loss of ignition. These effects must of course be considered when proportioning the fuel and air.

With oil, gas and the bin system of pulverized coal, fuel and air adjustment may be made practically simultaneous and should provide a quick response. Response is not instantaneous, however, and the gas travel around and through the furnace takes an appreciable period so in the interest of smoke prevention, the fuel supply is sometimes made to lag somewhat behind the air supply on load increase and to lead it slightly on load decreases. With stokers, however, the time required to increase or decrease the amount of coal in the furnace is considerable and the control of the air supply is the only quick method of changing the combustion rate. In unit mill systems it is sometimes desirable to introduce a time lag in the air supply to allow for the time taken by the coal in flowing through the mill. That is, the effect of the fuel feed is not apparent in the furnace for some time after the change takes place.

Fan Speed

Actual control of the air supply is by means of dampers, by means of speed changes of the fans or by a combination of both. Steam driven fans are easily controlled over a considerable speed range by means of the steam supply but motor driven fan control is not quite as flexible, usually being limited to a definite number of steps on the controller with a damper to give close regulation between steps.

Large stokers usually require air at several different pressures and it is necessary to provide several windbox dampers, for instance K, which may be adjusted to maintain constant or variable ratios under either manual or automatic adjustment, secondary to the main air supply adjustment. This is analagous to primary, secondary and sometimes tertiary air pressures in pulverized coal installations. Flow changes are of course the result of the controlled pressure variations, the higher the pressure the greater the flow.

Temperature of the air has an important influence on the rate of combustion but, like the superheat, is seldom controlled beyond that regulation given by the characteristic of the air heater so that its regulation does not complicate the control problem. Sometimes provision is made to bypass or recirculate some of the air at low ratings in order to prevent condensation and corrosion on the gas side of the heater and in the breeching. If used, this control is manual.

Air Measurement

The air supply is usually metered, for instance by an orifice E, by the pressure drop through some section of the duct, or, more commonly, by using the pressure drop or draft loss through a section of the boiler. By making certain assumptions and allowances for change in temperature this latter method is sufficiently accurate for practical purposes and changes in the condition of the boiler can be made periodically. This method measures not the air flow but the combined air flow and fuel flow which bears a definite relation to the steam flow. As with the steam flow, the volumetric gas flow varies as the square root of the pressure drop between the two points selected, for instance G and H.

In general, therefore, flow is closely regulated by changing the pressures at the desired points either by

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Central Station Equipment Proportions

By HAROLD M. WRIGHT

Instructor, Rensselaer Polytechnic Institute

A STEAM power plant whose component parts are proportioned in size and capacity to care for the duties required of them, and no more, would be an absurd proposition. It would be uneconomical, erratic in performance, and perhaps unsafe. Such a plant would be at the mercy of minor accidents and normal misbehavior on the part of any piece of apparatus.

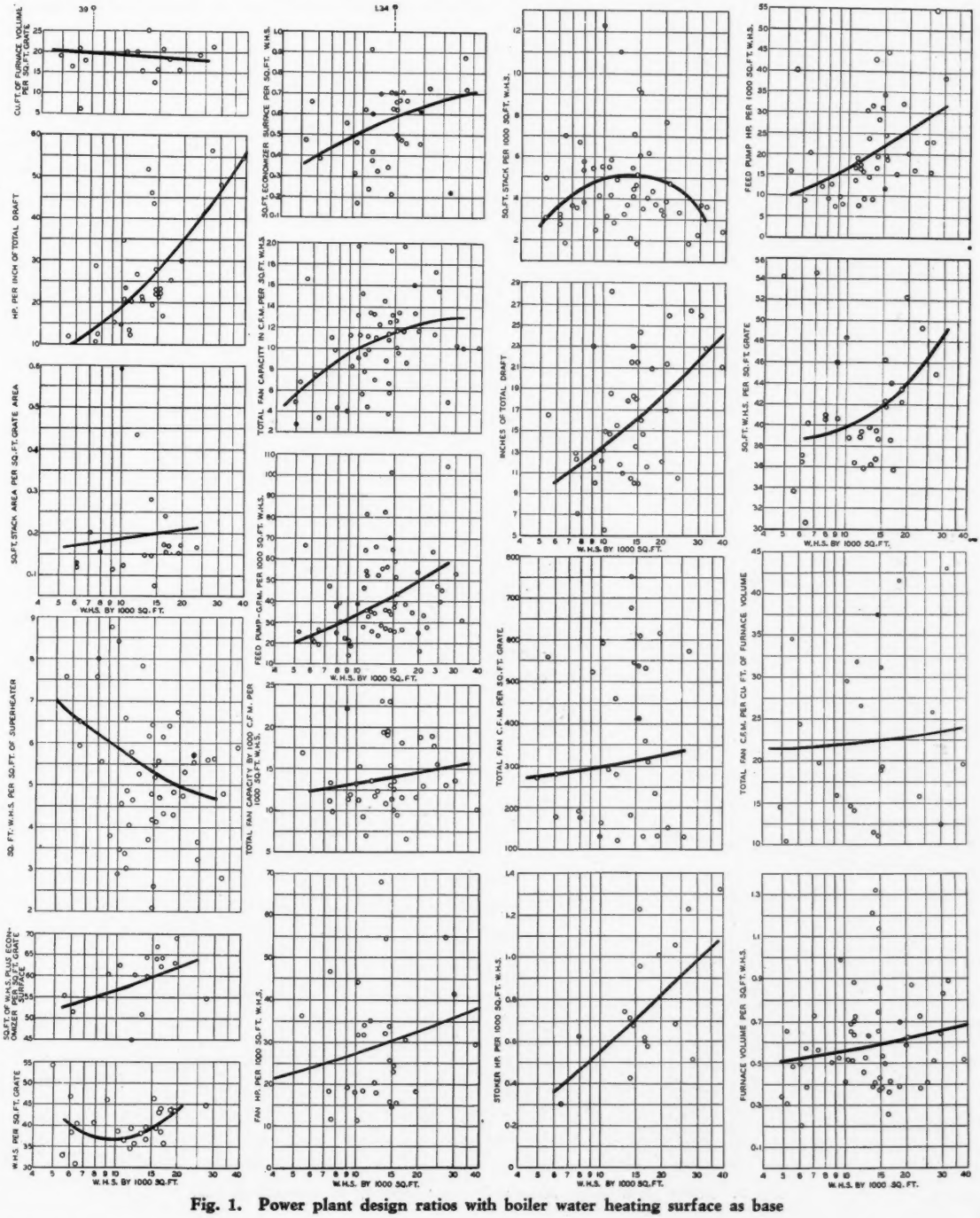

CU.FT. OF FURNACE VOLUME PER SQ.FT. GRATE
SQ.FT. ECONOMIZER SURFACE PER SQ.FT. W.H.S.
SQ.FT. STACK PER 1000 SQ.FT. W.H.S.
FEED PUMP HP. PER 1000 SQ.FT. W.H.S.
HP. PER INCH OF TOTAL DRAFT
TOTAL FAN CAPACITY IN C.F.M. PER SQ.FT. W.H.S.
INCHES OF TOTAL DRAFT
SQ.FT. W.H.S. PER SQ.FT. GRATE
SQ.FT. STACK AREA PER SQ.FT. GRATE AREA
FEED PUMP-G.P.M. PER 1000 SQ.FT. W.H.S.
TOTAL FAN C.F.M. PER 1000 SQ.FT. GRATE
TOTAL FAN C.F.M. PER CU. FT. OF FURNACE VOLUME
SQ. FT. W.H.S. PER SQ.FT. OF SUPERHEATER
TOTAL FAN CAPACITY BY 1000 C.F.M. PER 1000 SQ.FT. W.H.S.
SQ.FT. OF W.H.S. PLUS ECONOMIZER SURFACE PER SQ.FT. GRATE SURFACE
FAN HP. PER 1000 SQ.FT. W.H.S.
STOKER HP. PER 1000 SQ.FT. W.H.S.
FURNACE VOLUME PER SQ.FT. W.H.S.
W.H.S. PER SQ.FT. GRATE
W.H.S. BY 1000 SQ.FT.

Fig. 1. Power plant design ratios with boiler water heating surface as base

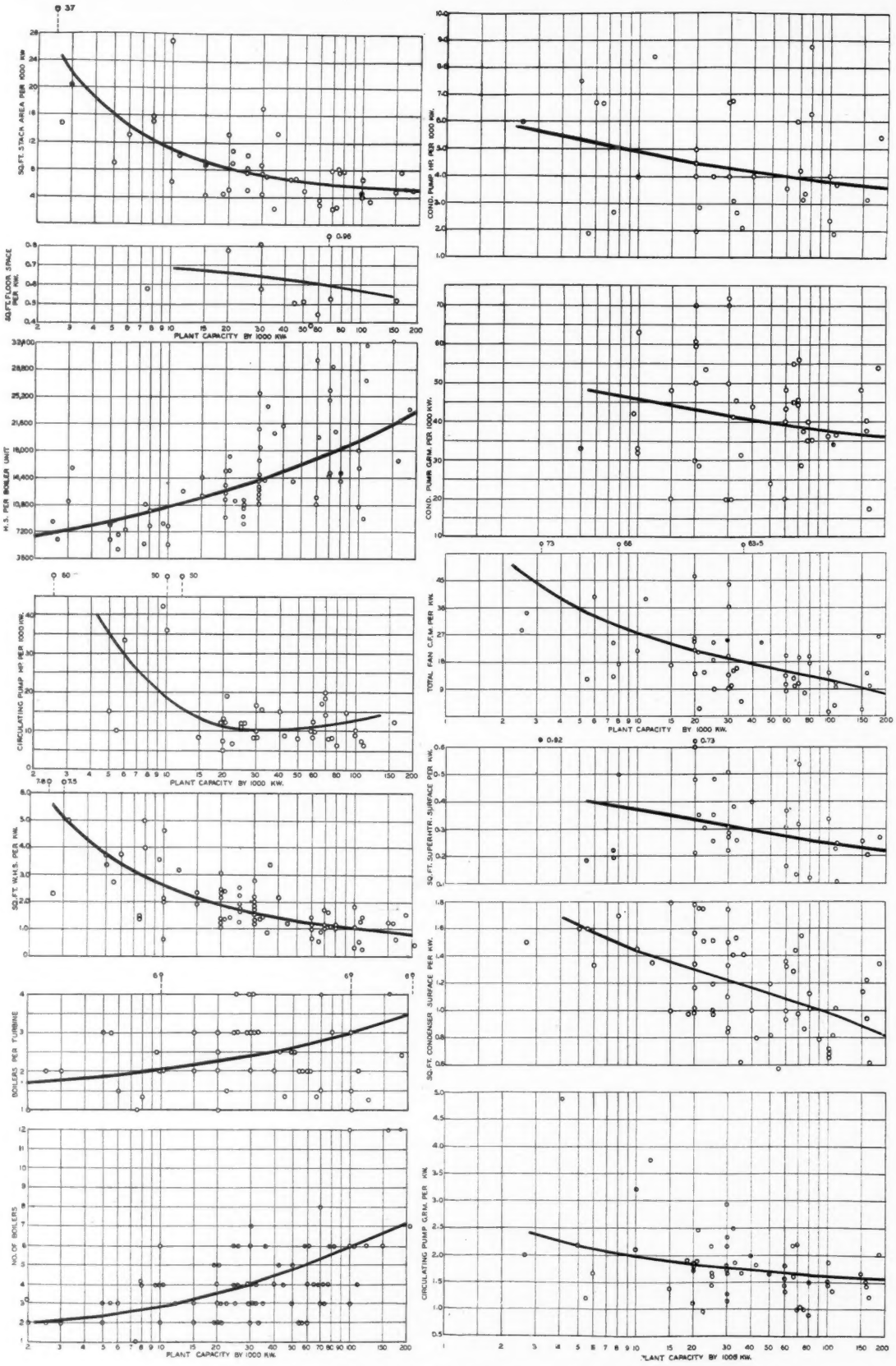

SQ.FT. STACK AREA PER 1000 KW
SQ.FT. FLOOR SPACE PER KW.
PLANT CAPACITY BY 1000 KW.
H.S. PER BOILER UNIT
CIRCULATING PUMP HP PER 1000 KW.
SQ.FT. W.H.S. PER KW.
BOILERS PER TURBINE
NO. OF BOILERS
COND. PUMP HP. PER 1000 KW.
COND. PUMP G.P.M. PER 1000 KW.
TOTAL FAN C.F.M. PER KW.
SQ.FT. SUPERHTR. SURFACE PER KW.
SQ.FT. CONDENSER SURFACE PER KW.
CIRCULATING PUMP G.P.M. PER KW.

Fig. 2. Power plant design ratios with plant capacity in kilowatts as base

Consider for a moment a plant whose unit parts are proportioned to care for plant full load only. One blown boiler tube would reduce station output by causing the entire boiler to be cut out. A boiler feed pump going bad would produce the same effect. Further, at full load on the boiler the pump would be incapable of raising the water level from any given point! The outage of a condensate pump servicing a large condenser would cause no small complication. A circulating pump suddenly failing to deliver normal output through failure, partial or complete, of the driving unit would have an effect not alone confined to the condenser pit.

Duplicate Units

The construction of such a plant is of course absurd. It could not be considered if reliability is a factor. Ample excess capacity is supplied to all units to provide for fluctuations and conditions. Duplication of many units is nearly mandatory. Just how far this excess capacity and proportion should go, is in the last analysis, a matter of opinion. No safety factor is an exact thing. This means that few plants, on breaking down their specifications, will show identical ratios.

The comparison, then, of pertinent ratios in existing plants is a matter of interest. Such a comparison is essentially a practical matter, for it indicates the trend of good engineering practice if compared to theoretical calculations.

For the purpose of making such a study, about 115 stations whose specifications were reported during the period 1926-32, have been analyzed. Their specifications have been broken down and recapitulated, resulting in the production of 32 curves showing the principal ratios. Due to the incomplete manner in which the stations were reported, no one curve represents 115 stations. This, however, should not make the curves valueless by any means. Two bases for these curves have been used: total kw. output of the plant and size of individual boiler expressed in square feet of water heating surface.

Trends Definitely Shown by Widely Scattered Points

A majority of these curves show a definite trend. Inspection of this group will show the points to lie fairly close to the weighted curve. In other cases a trend is observed, but with values taken from the curve open to question on account of the points being scattered all over the chart. On a few there will be apparently no trend at all, the ratio being fairly constant.

It should be borne in mind that if some of the curves show no trend, have badly scattered points, that they still possess merit. The very fact that they give negative information is of value, for such indicates extreme lack of agreement among designers or the relative unimportance assigned to that particular item. After all, this work is merely a report on plants as they have actually been constructed, hence will reflect personal opinion. This factor can never be put into the form of an equation.

Combustion Control

Cont. from page 164

the operation of dampers or by changing the speed of the fans. Temperature of the air is not regulated beyond the natural characteristics of the equipment.

5. FLUE GAS. The gases of combustion serve as the medium for conveying a large part of the heat of combustion to the boiler and when this has been done they may be considered as a byproduct of the process. Some day they may serve the further useful purpose of supplying solid and liquid CO_2 but at present they are discharged to the atmosphere as waste. Before this, however, they serve as an excellent guide to combustion condition, either from an analysis for the CO_2 content, or, from a measurement of flow as mentioned above in connection with the air supply.

Induced Draft Fans

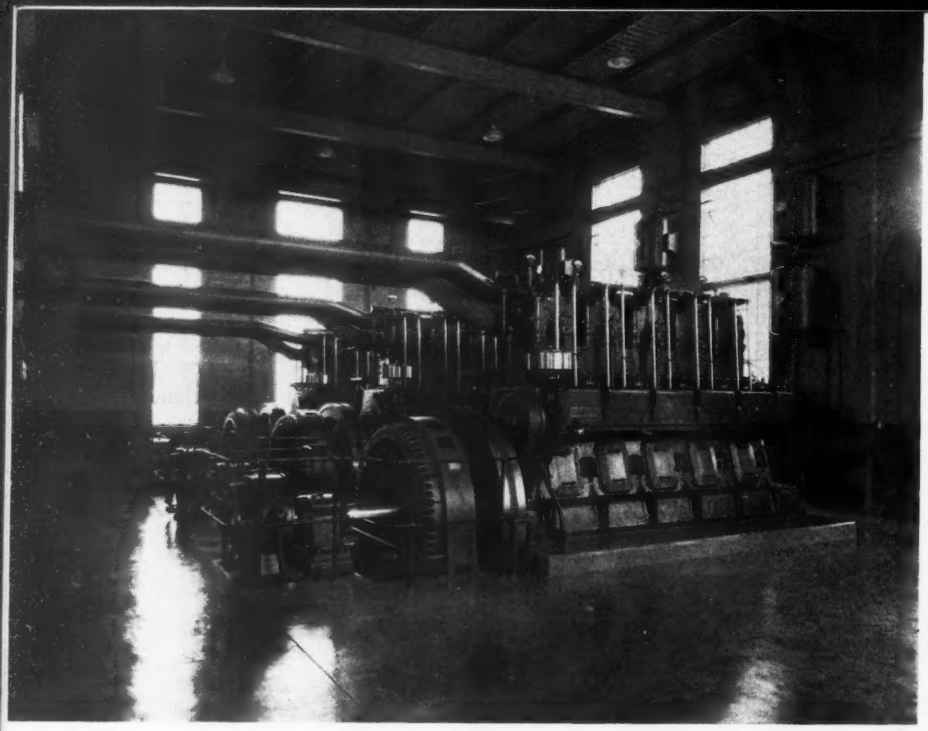
These gases must be removed from the furnace at the same rate as the fuel and air is supplied. In natural draft installations the stack must supply the necessary draft to overcome the pressure loss through the boiler and breeching but when an induced draft fan is used it takes over a portion of the task from the stack. The furnace pressure is usually maintained at or slightly below the atmosphere. If a positive pressure is maintained the hot gases could be forced out through the cracks in the setting to increase maintenance costs while if the draft is too high there is an excessive infiltration of air at locations which do not assist combustion and which may adversely affect the efficiency.

Temperature of the gases discharged is important from an efficiency standpoint and should be kept as low as the cost of heat absorbing surfaces permit. In any given installation the temperature increases with the steam output of the unit and it is largely due to this fact that the efficiency of the boiler drops off at the higher ratings.

In general, therefore, flue gases must be removed at the rate fuel and air are supplied, the draft (pressure) produced by the stack, or induced draft fan, must be sufficient to overcome the pressure loss through the boiler at the existing rate of flow. The temperature is primarily a function of the boiler rating but is controllable, within limits and indirectly, by adjustment of the fuel and air supply.

Summary

Thus the five factors, each with three variables, involved in boiler control, reduced, in the case of the usual control system, to the following: Control of fuel flow by means of stoker or feeder speed, or oil and gas pressure; control of air flow by pressure; control of flue gas flow by pressure. These changes must, however, be made so that the steam pressure is maintained practically constant by proportioning the heat release to the steam flow and, at the same time, the fuel, air and flue gas flows must be maintained at certain ratios to give the best possible combustion and to keep the furnace pressure at about atmospheric pressure.



Three De LaVergne engines totaling 1040 hp. were installed at total project cost of $162,875, of which about $44,275 was a PWA grant and $4,267 was charged to the adjacent water plant.

Culpepper, Va., *Municipal Diesel Plant*

AS THE RESULT of a referendum vote early in 1933, Culpepper, Va., retained Wiley & Wilson, consulting engineers of Richmond, to make a study of its power situation. These studies resulted in the decision to build a new power station, distribution and street lighting system which turned out to be the first municipal plant completed under the PWA.

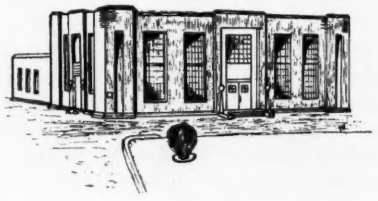
The annual load runs approximately 860,000 kw-hr. with a maximum demand of around 332 kw. so that it was decided to install two large and one small units, the combined capacity of any two, to be not less than 415 kw. so as to allow a safe margin and take care of immediate future growth. Modernization of the pumping plant was included and consisted primarily of replacing obsolete steam driven equipment with electrically driven centrifugal pumps and the retention of a Diesel pumping unit for standby service. The old pump house was replaced by a new building, designed to include a Diesel pumping unit and space for future expansion.

Three De LaVergne 15 by 18½ in., 300 r.p.m., 4 cycle, solid injection engines directly connected to Westinghouse 2300/4000 v., 3 phase, 60 cycle, 0.80 power factor generators were installed. Two of these are 5 cylinder, 400-hp. engines with 337½ kv-a. generators and the third a 3 cylinder, 240-hp. engine driving a 200 kv-a. generator. Due to the location of the plant, no air intake filters are installed but Maxim silencers are used on the engine exhaust and air intakes. The fuel oil system includes unloading facilities and the necessary Viking oil pumps, underground fuel pipeline and two 12,000 gal. above ground steel storage tanks, a 1000 gal. auxiliary underground fuel tank and a 100 gal. day tank for each engine.

The lubricating oil purifying system installed in the small room adjacent to the main engine room includes a Goulds Hydroil purifying unit with pumps and electric heaters. The engine cooling water is taken from an adjacent stream, by Nash self-priming centrifugal pumps. The cooling system also has an emergency city water connection opened automatically upon interruption of the pumping equipment. Compressed air for starting requirements is a Worthington gasoline engine driven unit with two receivers.

Total investment cost was approximately $162,875 which included a complete electric system as well as changes and additions to the Water Department pumping equipment. Allowing for the PWA grant, estimated at $44,275, total net cost to the city was $118,600. Buildings, grounds, engine foundations, crane, drainage and grading amounted to $19,244.70; engine generators, silencers, piping, oil tanks and filters, coolers, erection, etc., amounted to $61,680; mechanical equipment including oil storage tanks, purifying system, air compressors, cooling and heating systems, chemical tanks, etc., $13,817.26; and balance of the cost being divided between the electrical installation, street lighting system, pumping station, etc.

The project was administered by the light and power committee of the Culpepper town council, and the town manager, Victor von Gemmingen. Engineering work and supervision was by Wiley & Wilson.



The building is of simple but attractive architectural design

Combustion Chamber Design

AN ENTIRELY NEW METHOD of combustion chamber design has been developed in the Bohn Laboratories to control combustion in a manner to obtain maximum results with any given type of spark ignition engine. The principal design factors involved in the proportioning and forming of the combustion chamber with the new method are the location of the spark plugs, the effective length of the combustion chamber, the position of the intake valve, the rate of burning in consonance with piston travel and the compression ratio.

Inasmuch as the combustion time is effected by the length of the combustion chamber, in this design system the effective length of the chamber is proportioned with the stroke of the engine. By this method the flame propagation is timed with the movement of the piston and crankshaft, the object being, of course, to have the maximum pressures in the cylinder at the most advantageous crank angle for the greatest amount of engine torque. From this, it follows that the location of the spark plug in the chamber is important in determining combustion time and although the exact location of the plug may vary in accordance with the desired results, it has been found that particularly satisfactory operation is obtained by positioning the spark plug approximately 70 per cent of the distance between the valve centers away from the intake valve and substantially on a line passing through the valve centers.

Controlling the rate of burning in consonance with piston travel is not sufficient in itself to effect maximum combustion control, since the filling characteristics and the pressure rise per degree of crank travel are inseparably linked with combustion time in the working cycle. In the new method of design the ideal filling characteristics and pressure rise per degree of crank travel are assured by predetermining the dimensions of the critical portions of the chamber from the cubic inch displacement of the engine cylinder.

Velocity of flow of the fuel mixture into the chamber is determined largely by the area of the intake valve port. In order to secure the passage of sufficient fuel mixture through the intake port to properly fill the cylinder bore, the area of this port is proportioned from the displacement. Merely accurately proportioning the area of the intake port with reference to the bore displacement does not necessarily result in complete filling of the bore, however, since certain characteristics of the chamber affect the flow of fuel mixture from the intake port to the cylinder bore.

The throat area of the combustion chamber, or as it is often called, the venturi, controls, to some extent, the flow of fuel mixture from the intake port to the cylinder. Accordingly, to obtain maximum volumetric efficiency, this area is proportioned from the area of the intake port or cubic inch displacement of the bore. The designers have worked out a formula for the area of this throat; this formula is as follows: $A = D \div C$ where A is the throat area of the chamber, D is the displacement of the cylinder, and C represent a predetermined constant ranging from 17.5 to 18.5.

Other formulæ have also been developed for the effective length of the combustion chamber and for areas at different portions of the chamber depending upon the general characteristics of the engine. The total volume of the chamber is determined and dependent upon the particular compression ratio desired and the volume of the combustion chamber over the bore is preferably between 30 per cent to 35 per cent of the total volume, since it has been found that this percentage of volume over the cylinder bore provides proper control of the pressure rise per degree of crank angle.

Clearance of the combustion chamber around the intake valve is taken into consideration because of its effect upon the flow of the fuel mixture. The clearance varies in dependence upon the diameter of the intake valve and particularly satisfactory results have been found with a clearance which is approximately one-tenth of the valve diameter. The clearance around the exhaust valve is preferably slightly less than that around the intake valve, since in the usual engine construction the exhaust valve port has a smaller diameter than the intake valve port and the exhaust valve opens under pressure.

In putting this system into operation in a practical example, the designer first calculates the effective length L, of the combustion chamber from the formula $L = S \div K$, where the symbol S represents the stroke of the engine and the S a predetermined constant ranging from 1.5 to 1.55 depending upon type of fuel and compression ratio desired. After determining the length of the combustion chamber, the throat area or venturi area of the combustion chamber is determined, then the area of the combustion chamber at the bore, and finally the clearances around the valve. Some engines are capable of using higher compressions than others due to structural conditions, thus a rigid short engine like a V-8 can carry higher pressures than a long straight eight engine.

Ratios of from 6.3 to 6.5 have been found to be entirely satisfactory from a commercial standpoint using standard 70 Octane gasoline in a well designed rigid engine. Recognition is also taken in the design system of the Octane rating of the fuel. With fuel of higher than 70 Octane, for example, the effective length of the combustion chamber must be shorter to afford maximum combustion control, since this fuel will burn slower than the 70 Octane fuel. Thus the combustion time of the effective length of the combustion chamber must be reduced in order to obtain relationship between the points of maximum pressure and the top center position of the crank, with the slower burning fuel. On the other hand, with a more rapid burning fuel the effective length must be greater in order to obtain the desired relationship between the

points of maximum pressure and the top center position of the crank.

This design system is the result of a long series of laboratory experiments conducted in the Bohn Aluminum & Brass Corp. laboratory and in the field, for the purpose of reducing combustion chamber design to a concrete method and eliminating the trial and error system usually employed.

Maintenance of Diesel Engines

Air Bottles and Cooled Pistons Should Not Be Overlooked in Routine Inspection. By W. E. Warner

INSPECTION AND TESTING practice for air containers or air bottles shows little uniformity in different plants. An inquiry made by the Diesel Users Assn. of England, showed that the attention varied from a thorough annual inspection to no inspection. The wear and corrosion to which these cylinders are subjected are greatly affected by the humidity and dust content of the air. Where the air is reasonably clean or where filters are used and the humidity low, there is little trouble through wear and corrosion.

In all cases, however, a thorough annual inspection is to be recommended. A hydraulic test should be made at the same intervals, the test pressure being 50 per cent above the normal working pressure. Internal inspection is difficult but should be carried out as far as circumstances will permit, especially where erosion and corrosion are liable to occur as at the internal drain connections. If much wear has occurred suitable repairs should be made.

Suction Cleaning

Sometimes internal inspection will reveal deposits in the containers and these should be removed. They will usually be found to contain impurities from the air, with possibly metal filings and turnings which were left in the container after machining. Although the actual cleaning method adopted will be largely determined by the position of the inspection doors in the container, the easiest way to remove such deposits is by suction.

A suitable vacuum pump, pipework and nozzle will quickly suck up any such deposits and is the most effective methods for places not easily reached by ordinary cleaning methods. Protection from corrosion can be given by means of a coat of suitable lacquer or a solution of shellac and methylated spirits. If this is applied internally so as to give a continuous coating, any pitting or grooving of the metal will be prevented.

Piston Cooling Passages

Piston cooling may be by either oil or water. With oil cooling a good grade of oil is necessary, otherwise the high temperature may carbonize the oil especially if a vigorous circulation is not maintained. This is of more moment with two-stroke than four-stroke engines owing to the higher piston temperature in the former. With modern design and good oil the possibility of carbonization is not great and in one instance, a four-stroke engine cooling medium showed little signs of carbon deposit after 4 yr. service without cleaning but such long cleaning periods are not to be recommended.

When the piston rod is used to convey the coolant to and from the piston, these should be dismantled periodically, the internal tube withdrawn and the bore cleaned by a boiler brush or similar tool. Carefully examine for any signs of corrosion.

Annealing Copper Pipes

Where copper pipes are used to convey the coolant they should be annealed periodically as the operating conditions cause them to become brittle. This is particularly the case with long pipes which should be securely braced so as to prevent vibration. All joints should be carefully made as any leakage would cause inefficient piston cooling as well as contaminating the oil in the crankcase. The continual vibration and the hot liquid make leakages always probable. Thin leather of good quality makes an excellent joint.

Screwed Joints

The piston cooling arrangements should be cleaned and inspected each time the engine is overhauled. Corrosion is always likely to occur. Inspect carefully for this especially at any screwed connections or joints. Those parts of the pipe not accessible for internal cleaning should be blown through with live steam. This will remove any deposit which may have collected. The whole piston cooling arrangements must be kept in perfect condition as any failure will affect the safety and efficiency of the engine.

Boulder Dam Gate Closed

IN THE FIRST five days after lowering the gate at Boulder Dam on Friday, February 1, the storage waters in the 115 mile reservoir rose 25 to 30 ft. This storage is in addition to the water which is being allowed to pass through the dam to meet the present needs of the country below. Engineers estimated that Boulder Dam will be ready to begin furnishing power by the middle of the year if the present rate of flow keeps up. After only three days of storage the elevation of water in the reservoir was about one-seventeenth of that needed to generate power. Now the gate closure has been made it is proposed during the coming year to release only the amount of water actually required for irrigation and related purposes unless weather conditions should develop which would result in a much higher run off than now indicated. The balance of the water will back up behind the dam to be held in the reservoir until needed.

The power plant which is now under construction at Boulder Dam will not be completed until 1940, but some of the generators probably will begin to generate power in 1935. This power has already been contracted for by the city of Los Angeles and the Southern Sierra Power Company.

Proposed
New York License Law for Stationary Engineers

A BILL HAS BEEN introduced into the New York State Senate to amend the general city law as to licensing of engineers, making the establishment of licensing and of power plant inspection compulsory in all cities of less than 1,000,000 population. Where examining boards exist, they are to be continued. In other cities, they are to be established.

Each board is to have at least three members to be appointed by the mayor for a term of 3 yr., except the chief examiner whose term is indefinite. Requirement for examiners is an operating engineer with not less than 8 yr. experience in supervision or in charge of a plant or plants developing 150 hp. or more. The chief examiner is to be a resident appointed from the municipal civil service list and his pay is to be fixed by the governing board of the city. Other examiners are to receive $5 for each session of the board but not more than $10 a month. Meetings are to be held on written notice from the chief examiner, not more than twice a month.

The board is to formulate code of rules for qualifications of second, first and chief's classes; to examine all applicants and issue licenses; to collect such fees as shall be set by the governing board of the city for examination and for issue and annual renewal of licenses and to pay over such fees to the city treasurer. The fees are to be set to cover the cost of operating the board.

Engineers who, during 5 yr. preceding their application for license, have been employed for 36 mo. total in the operation of a boiler, engine or other machine for which license may hereafter be required are entitled to licenses without examination, if application is made within 3 mo. after the law becomes effective, that date being set as Jan. 1, 1936.

Licenses are to be of three classes: chief engineer, capable of taking charge of over 150 hp., who holds first class license and has had at least 3 yr. experience in a plant of over 75 hp.; first class, competent to take charge of 75 to 150 hp., who holds second class license and has had at least 2 yr. experience in a plant of over 30 hp.; second class, competent to take charge of 75 hp. or less and has had 3 yr. experience in operation of power development units All licenses expire 1 yr. from date and may be renewed within 30 days before examination.

Inspectors, for plants not covered by the state boiler code, not more than two in cities of under 1,000,000 population, *may* be appointed by the mayor from a municipal civil service list to be prepared from examinations by the city civil service commission. Inspectors must be licensed chief engineers, must not work as stationary engineers during the period that they act as inspectors, must be residents and their pay is to be fixed by the governing board of the city. In addition to duties prescribed by law and those required by the chief examiner, they are to inspect installation and operation of all power plants and report the results in writing to the chief examiner and the board; also report any one acting as stationary engineer without license.

Offices and supplies are to be provided and clerical help may be authorized by the city council. Expenses are to be included in the tax levy, but after the first year shall not exceed the amount of fees collected during the preceding year.

Requirements of the act apply to: all steam plants carrying 15 lb. pressure or over or developing over 30 hp.; all refrigerating plants of over 20 t. capacity; compressors of over 110 cu. ft. a min.; generator or pump of 30 hp. or more. Locomotives and steamboats are exempt.

Further information can be had from the New York State Board of Boiler Inspection, Albany, N. Y., and New York State engineers who may be interested in the passage of the bill can secure petitions from Charles H. Mundt, 316 Grey St., Buffalo, N. Y.

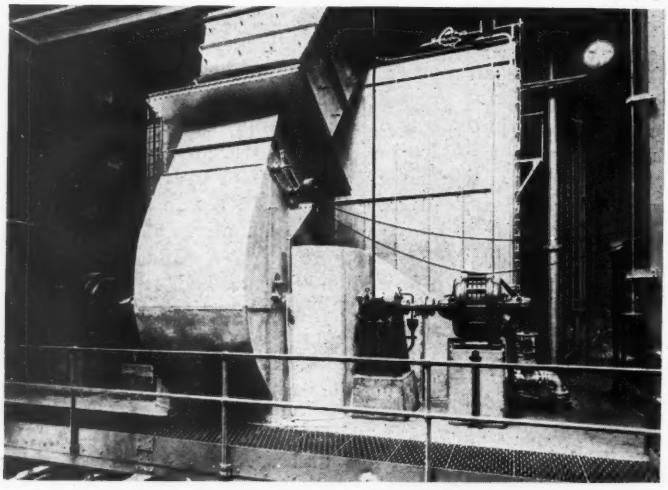
CONTROL OF SCALE and corrosion in a hot water system while similar in principle to control in boiler work is essentially different due to the fact that there is no opportunity for concentration of chemicals in the system. Treatment is introduced, flows through the pipe line and out with the water requiring the constant introduction of treatment in order to prevent the passage of untreated water through the system.

Corrosion is generally the most important factor influencing the adoption of hot water treatment and the causes of corrosion may be listed as low pH, high oxygen content, carbon dioxide, comparatively strong solutions of electrolytes and the presence of dissimilar metals which cause electrolysis. As a general rule, no one of these factors is individually responsible for corrosion but a combination of two or more such as oxygen in the presence of a low pH, or oxygen in the presence of carbon dioxide, carbon dioxide in the presence of dissimilar metals or a low pH in the presence of strong electrolytes or some similar combination which requires correction.

The fundamental step in correcting corrosion in hot water lines is the correction of pH value which in all cases should be maintained at a value in excess of 8.5 and frequently at higher values. The control of oxygen requires the use of materials which will remove this directly from the water and this may be accomplished either through the use of direct chemical reactions or by the use of deaerators.

Presence of electrolytes in large enough concentrations to cause trouble requires the careful selection of buffers and the advice of a competent chemist. In some instances, it may be desirable to protect only the hot water tank or heater due to the fact that some corrosion resistant piping is used throughout the hot water system itself. H. O. H. NEWS.

Electrically Driven Auxiliaries *for Steam Generating Stations*



By S. C. SMITH

Industrial Engineering Dept.
General Electric Co.

In a previous article the author presented the important aspects of modern electric drives in steam generating stations. In this article the discussion is continued to include the factors involved in the control of electric motors for this class of service.

IN A PREVIOUS ARTICLE[1] we discussed in some detail the principal factors involved in the electric operation of auxiliary equipment in steam generating stations and described the various kinds of motors available for this service. Since all motor operation is more or less intimately related to control equipment, we will in this article consider the factors involved in motor control.

As a first essential it may be stated that the control for power station service must be as reliable and simple as possible.

Starting current limitations, in general, are sufficiently liberal to permit starting squirrel-cage induction motors on full voltage, thus simplifying the control problem to a considerable extent.

Control equipment for the "essential" or "non-essential" auxiliaries requires special consideration with regard to the short-circuit duty requirements of the switching equipment where there is a high concentration of power behind the low voltage bus to the motors. The control selected should have adequate interrupting capacity to clear any fault without interfering with the operating of any of the other auxiliary drives. Circuit breakers are designed primarily as circuit switching devices; contactors are designed as motor control devices, and are better suited for frequent operation.

Since the motors may be on the line for long periods of time without being taken out of service, contactors conservatively rated should be selected to minimize oxidation, which causes heating of contact surfaces.

Undervoltage protection is usually omitted on "essential" drives as the motors should restart automatically on return of voltage after an interruption.

Overload protection is frequently omitted for important auxiliaries. If the motors are selected properly, overloads should not occur except in cases of mechanical failure. When provided, it is sometimes considered preferable to arrange the relays to operate an alarm circuit rather than to shut down the motor.

Undervoltage and overload protection are normally provided for non-essential auxiliaries.

The control for the various types of motors will now be discussed separately. Only the principal points will be mentioned since for many power stations the control will require special interlocking between two or more drives, and additional equipment to meet the particular requirement of the purchaser is nearly always desired.

Squirrel-Cage Motor Control

Full-voltage starting is standard practice, as previously pointed out. The control for single-speed motors would then consist of a line switch large enough to handle the full load and inrush motor currents and possessing sufficient interrupting capacity. This switch should be of either the circuit breaker or magnetic contactor type, depending on the power supply.

Control for multi-speed squirrel-cage motors is similar to that for single speed motors except that means for changing speed must be provided.

The use of reduced-voltage reactor starting for single- or multi-speed squirrel-cage motors is practically limited to very large motors. Auto-transformer starting should not be used on essential auxiliaries nor any auxiliaries above 600 v., as a general rule.

[1]Page 108, Feb., 1935.

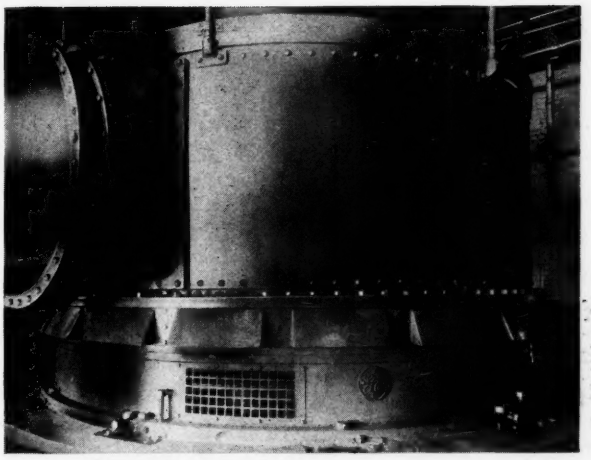


Fig. 1. 500 hp. 72 r.p.m. vertical synchronous motor mounted under a 51 ton pulverizer

B. Wound Rotor Motor Control

The primary control is similar to the control for squirrel-cage motors started on full voltage and may be arranged for either hand or automatic operation. The secondary control should consist of drum controller (hand, chain, or pilot motor operated) together with starting and speed regulating resistance.

The control for motors on essential drives should be arranged so that, in case of voltage failure, the motors will immediately restart when voltage is restored. This may require an additional block of resistance which is automatically connected in the secondary circuit when the voltage falls to approximately 50 per cent and which is cut out after the voltage rises to approximately 80 per cent.

C. A.-C. Brush-Shifting Control

The control required for most of these motors consists simply of a suitable line switch and, if the brushes are shifted by a pilot motor, suitable control for the pilot motor. The motors are started on full voltage with the brushes usually in the slow speed position, since for this position of the brushes the starting current is low and the starting torque ample for most drives.

D. Direct Current Motor Control

Direct current motors, except those of very small size, are practically always started with resistance in series with the armature to limit the starting current to a reasonable value. Most direct current motors used to drive the auxiliaries are operated on constant armature voltage. Adjustable speed, where necessary, is obtained manually or automatically by varying the field strength with a rheostat.

E. Automatic Feedwater and Combustion Control

Automatic control maintains desired conditions more closely than hand control and minimizes the number of operators desired.

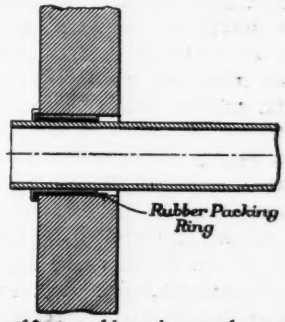
Feedwater control, of the automatic type, is often applied to adjustable speed wound-rotor motors driving boiler feed pumps. In all cases, a pressure regulator is used to control the motor speed. Either a constant pressure or differential pressure regulator may operate the secondary switch of the wound-rotor motor hydraulically or electrically.

Combustion control designed for either mechanical or electrical operation may be applied to motors driving draft fans. Both types are used for wound rotor motors while the electrical type is usually employed for controlling multi-speed or brush-shifting type of a.c. motors.

Trebovice Station Czechoslovakia

ONE OF THE INTERESTING and most modern of the European central stations is the Trebovice Power Station in Silesia, Czechoslovakia. It is at the northeastern border of Silesia near Svinov-Vitkovice on the River Oppa, a tributary of the River Oder and accessible to a number of collieries. It is a cooperative project of the Moravia and Silesia Electricity Co. and the Central Moravia Electricity Co., 60 per cent of the capital of the two companies being held by the state or by communal or public bodies.

The station contains two 21,000 kw. Skoda turbines and the present building will allow a total installed capacity of 70,000 kw. while the site will permit extensions up to 150,000 kw. Three Loeffler boilers fired by pulverized coal are installed. Two of the boilers are equipped with two impact mills, the third boiler with a tube mill. Normal boiler capacity is about 130,000 lb. of steam per hour and the maximum 165,000 lb. per hour. Steam conditions are 1850 lb. pressure, 930 deg. F.



Type of rubber packing ring used on condensers

In addition to the main boiler there are two 22,000 lb. per hour Babcock 300 lb. boilers to supply steam to the make-up in the 1850 lb. circuit and to supply the house turbine.

Condensers have a cooling surface of 21,500 sq. ft. and are designed to handle 154,000 lb. of steam per hour each. Circulating water will be supplied from cooling towers. Welded condenser shells are used and the condenser tubes are packed with rubber rings as shown by the accompanying drawing reproduced from Engineering. These rings are said to form a tight joint and to give long service.

Three extraction heaters are used, final feed water temperature being about 324 deg. F. The low pressure heaters have welded shells with brass tubes expanded into the tube plates at each end. The high pressure heaters have one end expanded and the other packed with Crane metallic packing.

"ELECTRONICS" Enters

A General Report of the Technical Papers Presented at the Winter Convention of the American Institute of Electrical Engineers at New York During Week of January 21

THE ANNUAL Winter Convention of the American Institute of Electrical Engineers held in New York during the week of January 21, this year, as in other years, was replete with a wide variety of professional and social events; some indeed, of outstanding importance. The many technical sessions were well attended and they were conducted with a precision that was well befitting of an engineering society. Despite the severe snowstorm which occurred during the convention the total registration was 1114. All the papers presented at this convention—and there were some fifty of them, had been published in "Electrical Engineering" prior to the convention, some as early as last August, the others in later issues.

The papers themselves, as already implied, were of unusual interest and several of them described new developments which will undoubtedly have a profound effect upon the future transmission and utilization of electric power. Things are happening very rapidly in the art of electricity and some of the matters discussed seriously at this meeting, only a few years ago, would have been regarded as the dreams of an uninformed idealist. The rapid development of the art, of a related art in particular, i.e., that of illumination, was eloquently described by A. L. Powell's demonstration lecture on Wednesday evening, January 23. This particular meeting was one of the high points of the convention, for not only was it the occasion for this most interesting demonstration, but at this same meeting Dr. Willis R. Whitney of the General Electric Co. was presented the Edison medal. Also, at the same time, the John Fritz medal was presented to the family of the late Frank J. Sprague. Mr. Powell's lecture which followed the presentation of the medals, and Mr. Powell, by the way, is president of the Illuminating Engineering Society, was on the subject of "Artificial Light—the Engineer's greatest gift to mankind." By the aid of a stage full of apparatus and several assistants, he traced the development of illumination over a period of 500,000 years, more or less. His first demonstration consisted in lighting, rather unsuccessfully at that, a small pine splinter. This, the rude pine knot, was man's first illuminant. How many centuries this took to evolve Mr. Powell could not say but it was a long time and represented by far the greatest part of the time span considered in this lecture. Next came the first crude whaleoil lamp, and then the candle, the coal oil lamp, etc., but all these developments Mr. Powell pointed out were of comparatively recent origin —the latter, that is the coal oil lamp, dating back only some 75 years. And then 55 years ago came a new source of illumination, electric light and from this point on, the lecturer described the rapid development of the art of electric illumination. This compared to all that had gone on previously represented an astonishing acceleration in the development of the art of lighting, but what was more startling was the fact that nearly the whole of Mr. Powell's lecture and nearly all of the equipment on the stage—and there was a considerable quantity of it—was concerned with developments in "illumination" during the past year or *eighteen months*! It makes one wonder just where we are headed.

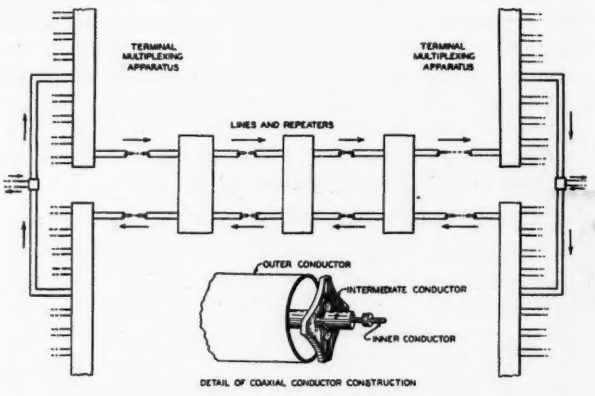


Fig. 1. Diagram of Coaxial transmission system

And if development is spreading at a constantly accelerating pace in the field of illumination, the same is true of electrical engineering in general. Indeed, it was of fundamental significance that at this meeting the only subject on which two sessions were held at this convention was the subject of "electronics." Only a few years ago, the electron to the average practical

Heavy Power Field

Electronic Devices have had considerable application in industry in connection with control operations and in regulating equipment, but until recently they have not been used for carrying heavy power except in one or two experimental cases. Now, however, as described in the A.I.E.E. papers presented at the Winter Convention, Electron tubes are proposed for heavy power circuits to carry large power. The direct current transmission system and the Thyratron motor, both using electron tubes, were the subjects of greatest discussion at this meeting.

electrical engineer, was little more than an interesting theory, and electronic devices, what few there were, were considered of use only in the communication field and there only to a limited extent. Yet, today, electronic devices are of such importance to the heavy power electrical engineer that two entire sessions are required to discuss the recent developments in this particular branch of the art. This increased use of the electron tube in industrial practice has been brought about despite the usual amount of opposition directed toward any new idea by the so-called conservatives. The vacuum tube, which exemplifies the electronic device more than any other, was born of the radio industry and was carried through its infancy by the communication engineers. Always progressive, years ahead of commercial requirements in fact, the communication engineer needed no urging to use this new device and within the short space of a few years he made it the very foundation of the communication art. The entire communication art today is built around the electron tube. Gradually, however, its marvelous powers began to be recognized in other fields and gradually a few applications began to be made, but the newcomer from the radio field was not regarded with a great deal of enthusiasm except by a few—those whose vision and foresight always set them apart from the average regardless of the field. And so the electron tube today looks to a future in which it will take its place in the field of heavy power engineering where its service probably will be as far reaching as it has been in the field of communication.

It is of course impossible in a short report such as this to describe all the papers in detail but an attempt will be made to consider the most important ones.

Twelve Technical Sessions

In all, there were twelve technical sessions, as follows:

Tuesday, January 22. A, Electrical Machinery; B, Communication; C, Transformer symposium; D, Education.

Wednesday, January 23. E, General overhead line problems; F, Noise symposium; G, Illumination; H, Electric welding.

Thursday, January 24. I, Electronics symposium; J, Cables; K, Electronics symposium; L, Induction motor symposium.

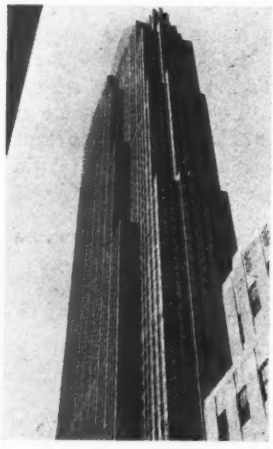
Electrical Machinery

There were three papers presented at the electrical machinery session on Tuesday, one on Heat Flow in Turbine Generator Rotors, another on the Output Wave Shape of Controlled Rectifiers, and the third, on Transients in Magnetic Systems. These papers were for the most part of interest to the designer, dealing with more or less complex details of design theory. In the paper on heat flow in generator rotors for example the problem involved is the accurate predetermination of temperature so as to account for the differential expansion of coils and coil strands and the safe operating temperatures of the field coil insulation. C. E. Peck of Westinghouse who presented this paper showed that a large number of variables can be taken into account in a relatively simple manner and that his method of analysis can be applied with accuracy to all sizes and types of turbine generators.

Communication

The entire communication session was taken up almost entirely with a consideration of wide band transmission lines. In connection with the transmission of musical programs over long distance lines it is apparent that in the future it will be economically advantageous to make use of considerably wider frequency ranges than are now in use. Also, the possibilities of television have come into active consideration and for reasonably high definition a band on the order of 100 kc or more is essential. This has led the communication engineers to devote considerable research in this direction recently and new methods have been developed for constructing such wide range circuits.

The existing types of wire circuits can be worked to frequencies of tens of thousands of cycles as is evidenced by the widespread application of carrier systems to the open wire telephone plant and cable systems. Such circuits, however, for the protection against external interference, must be balanced and as the frequency band is widened, it becomes more and more difficult to maintain a sufficiently high degree of balance. Another form of circuit has been developed which differs from existing types in that it is unbalanced (one of the conductors being grounded).



RADIO CITY

Radio City was one of many points of interest for those attending the convention. Over 140 members visited this great development. Other trips of interest were the G. E. House of Magic, the Radio Patrol System of the N. Y. Police Dept., the Kearny Station of the Public Service of N. J. and the Hudson avenue station of the Brooklyn Edison Co.

This is the coaxial or concentric circuit. It consists essentially of an outer conducting tube which envelopes a centrally disposed conductor. The high frequency transmission circuit is formed between the inner surface of the outer conductor and the outer surface of the inner conductor.

The fact that it is difficult to balance the ordinary type of line at high frequencies does not necessarily imply that new methods cannot be developed for solving the problem, and considerable work has been done in that direction recently.

This session therefore was of particular interest. Three papers were presented on this subject, two dealing with wide band transmission over coaxial lines and one with wide band transmission over balanced circuits, all by members of the Bell Telephone Laboratories. One of the first two, presented by S. A. Schelkunoff, was a non-mathematical discussion of the structure features of the coaxial system. Floyd Espenschied and M. E. Strieby then presented a discussion of wide band transmission over such a system which was followed by a paper by A. B. Clark on balanced circuits.

A significant fact, indicative of the advanced state of the electrical communication art, was brought out in Mr. Espenschied's presentation. This was the statement that such a wide band transmission line as he described—approximately a million cycles wide, was sufficient to take care of 200 ordinary telephone channels. Of course no such capacity is needed at the present time in the telephone art, but should it be necessary at any time, the communication engineer will have it ready. A television system it was pointed out would need the entire frequency band of a million cycles for effective performance.

Transformer Symposium

Two of the papers at the transformer symposium dealt with the effects of overloading. L. C. Nichols of Allis-Chalmers presented a paper on the effects of overloads on transformer life and V. M. Montsinger of General Electric and W. M. Dann of Westinghouse presented another. The latter was a report prepared under the sponsorship of the transformer subcommittee of the A.I.E.E. committee on electrical machinery. The recommendations regarding short time overloading in this paper take advantage of the heat storage capacities of the materials in the transformer and are intended to supplement present recommendations relating to continuous overloading that is possible when the ambient temperature is lower than the standard ambient temperature. As an example, it is shown that with an ambient temperature of 40 deg. a transformer can be subjected to an emergency load of 25 times the continuous rating for a period of two seconds or of nine times continuous rating for 10 seconds.

Mr. Nichols in his paper showed that transformers can be overloaded considerably for short periods with little loss in life. These two papers were very interesting and gave definite information on questions which no doubt have arisen in the minds of many operators when because of emergency it was necessary to impose great overloads on transformers under their care.

Education

For a number of years the question of engineering education has been given a great deal of consideration by the Institute. There has been much criticism of methods of schooling for engineers and in recent years when positions have grown scarce there has been considerable effort made to improve conditions and to correct some of the older methods. Harold W. Bibber's paper, "Engineering Education is Meeting the Challenge" presented at the session on education, showed new courses, new methods of instruction in engineering schools in meeting the challenge of industry in this respect.

Speaking from years' of experience in employing and handling engineers, the paper by Alex Dow, president of the Detroit Edison Co., on the schooling of engineers was of outstanding interest. Mr. Dow considered two types of students, one fundamentally interested only in engineering and the other more deeply interested in and capable of leadership. Among the numerous points which Mr. Dow stated should be brought to the attention of the student engineer is the necessity of realizing that human relationships, which cannot be reduced to a science are among the most important considerations in later life.

Looking at the question of engineering from the social point of view, J. C. Lincoln of the Lincoln Electric Co., presented a paper on Engineering in the Social Sciences. Mr. Lincoln pointed out that "all wealth is produced from land by the application of labor aided by capital. In order that every one might have an opportunity of securing his rightful share of land, he proposed a new system wherein every community would collect all community created-ground rent and all taxation on wealth would be abolished. The last of the four papers presented at the session on Education was a very interesting one by Thos. Spooner of the Westinghouse Co., in which he analyzed the Characteristics of a Group of Engineers—research engineers.

General Overhead Line Problems

This was unquestionably the most important session of the entire convention because of the paper presented by C. H. Willis of Princeton University and B. D. Bedford and F. R. Elder of the General Elec-

tric Co. on Constant-Current D.C. Transmission. The substance of this paper was presented on page 126 of the February issue, but a brief outline of the system described by the authors will be repeated here. It represents a new system of high voltage direct current transmission embodying conversion of constant potential a.c. power to constant current d.c. power, transmission of constant current d.c. power, and reconversion to constant-potential a.c. power. The promising features of this system are its unusal stability and reliability.

The simple elements of this system of transmission are shown in Fig. 2. This being a simplified circuit diagram of the 150 kw., 1500 v., 10 amp. system first set up in the laboratory. This was the system upon which the paper was based, but since the paper was written and since this laboratory set up was constructed, a much larger installation was constructed and placed in operation. This large system was announced and described at the convention.

This large system is exactly like the small system but is rated at 3000 kw., transmitting a constant direct current of 200 amp. at 15,000 v. It has been set up in one of the factory buildings at Schenectady and is connected to the 13,800 v., 60 cycle, 3 phase, alternating current bus of the New York Power and Light Corporation. The circuit includes about 15,000 ft. of underground conductor and is connected back to the 13,800 v. bus after being inverted from direct to alternating current of the proper characteristics.

The monocyclic network used in this circuit is based upon the principle of the series resonant circuit invented by Boucherot some 45 years ago and shown in Fig. 3. This circuit was used for transforming constant voltage into constant current for arc lights.

Naturally this paper was received with great interest and invoked much discussion.

C. W. Stone and Dr. Alexanderson, both of the General Electric, were both enthusiastic over this development. As Mr. Stone pointed out, in this scheme we obtain for the joint time full control of the amount of power transmitted in each direction. The losses he said are so small in this 3000 kw. system that they can almost be neglected. He further pointed out that with all the discussion regarding lightning and lightning protection which had preceded the presentation of this paper, the commercial development of this direct current system of transmission would make such discussion superfluous. With the direct current system many of our ordinary lightning troubles would disappear.

Dr. Alexanderson said that the objective of this development was to reduce the cost and extend the range of transmission lines.

Mr. Hellmond of the Westinghouse Co. was not so certain, however, that this system possessed quite as much merit as its proponents claimed. He expressed doubts regarding the operation of the mercury vapor tubes with respect to speed of firing, although he thought perhaps that might be corrected by the use of devices incorporating the "ignitron" principle. Despite the perfection to which the designers had brought this experimental equipment, he felt that there would not be many instances of constant current d.c. transmission in the near future.

Philip Sporn of the American Gas & Electric Co. took a more enthusiastic standpoint without being overly optimistic. While he felt that this system had possibilities, he still felt that ten years from now most of our power would still be transmitted as a.c. In his discussion he referred to previous uses of constant current—the Thury system in Europe and pointed out this system was different because of the use of Thyratron tubes. He had made rough calculations as to the relative advantages of the d.c. system as compared with an a.c. system which showed that under certain conditions conversion of an a.c. transmission line into a

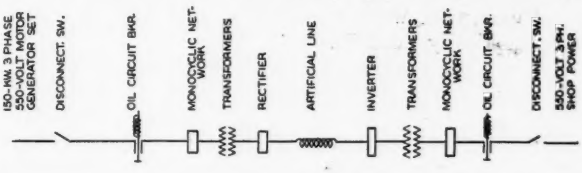


Fig. 2. Diagram showing elements at D. C. Constant Current Transmission System

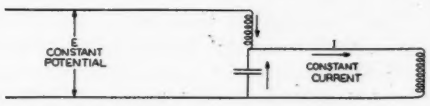


Fig. 3. Simple Monocyclic System

d.c. line would result in a gain of 41.4%. This was in the case of a double, 3 wire, a.c. circuit. In other instances this gain was less and in some the advantage was with the a.c. system.

Another factor that should be considered, Mr. Sporn pointed out was insulator performance under high tension direct current. This he said would require considerable study, and investigation was necessary because we know very little about the action of insulators under high tension direct current over long periods of operation. It is well known he said that high unidirectional fields cause precipitation of dust on insulators. The question of harmonic distortion of the wave shape was also of importance as it vitally affected telephone interference.

In pointing out this problem Mr. Sporn implied that he in no way wished to detract from the importance of this development. It was extremely interesting and he complimented the authors of the paper in having done a brilliant piece of research.

Dr. Fortesque of Westinghouse questioned the economic feasibility of the system, pointing out the high cost of the equipment involved in the monocyclic network. He felt that the constant current system was not necessarily advantageous and that for transmitting large blocks of power over long distances, constant potential is better than constant current.

H. W. Eales of the Byllesby Co. was very enthusiastic in his discussion of the paper. He said he wished to take a middle course in regard to the criticism of the system. He considered it an epoch making paper. He had seen the large system in operation at Schenectady and did not agree with Phillip Sporn in his opin-

ions regarding the future use of the system. Rome was not built in a day and he felt that we were on the threshold of a major development in the power field. He felt that this problem would be solved and with due respect for Mr. Sporn's calculations, he thought that the d.c. system could be operated at a much higher voltage than an a.c. system. He did not wish to give the impression that he thought this development a panacea for all transmission troubles but it had its place and its adoption would extend the capabilities of our present systems.

Herman Halpern of the Commonwealth Edison Co. also presented a brief discussion of this paper. He discussed its use in a metropolitan district such as the Chicago area and his conclusions seemed to be that a great deal more work would have to be done to make it economically possible.

In closing the paper, Dr. Willis, one of the co-authors of the paper, sympathized with Dr. Hellmond in his inability to see the merits of the system. He pointed out that in thinking about these matters we all find ourselves in a strong constant potential state of polarization. As to Mr. Hellmond's criticism regarding the possibilities of arcing on large systems, he said this system cannot sustain an arc—this had been proved. The deionization time, also, was no factor. Dr. Willis also felt that Dr. Fortesque was very much confused in his ideas about monocyclic networks and thought probably he had read Steinmetz's theory on monocyclic networks. In Steinmetz's book, he said every reference to monocyclic networks, is wrong.

Finally, he referred to the short time that it had taken them to develop the system. They began work on it less than one year ago. He said that he felt the next important step would be for some operating company to try it out in actual commercial service.

Lightning Performance

There were several papers presented at the Overhead Line Session dealing with lightning problems. The first of these dealt with lightning performance on 220-kv. lines. This was a report of the Lightning and Insulator Sub-committee of the Institute.

In addition to this paper on lightning performance at 220-kv. lines, there was another paper on lightning phenomena which was of considerable interest. This was the paper on Multiple Lightning Strokes presented by K. B. McEachron. Multiple lightning strokes have long been known to exist but until recently instruments for recording the successive discharges on electric power lines have not been available.

The application of the expulsion protective gaps to three typical transmission lines, however, made a partial investigation possible with the aid of the automatic oscillograph. The results of this investigation were presented by Mr. McEachron in his paper. He pointed out that as many as 12 successive discharges have been reported in a single stroke. These discharges were shown to be as close together as one cycle (on a 60 cycle system) and as far apart as 9½ cycles. The expulsion protective gap referred to in Mr. McEachron's paper received further consideration in a paper by Philip Sporn and I. W. Gross, both of the American Gas and Electric Co., in a paper entitled "Expulsion Protective Gaps on 132-Kv. Lines."

In this discussion of these papers it was pointed out that while it was interesting and noteworthy that lines could be made practically 100 per cent lightning proof by means of such devices as expulsion protective gaps, a more logical solution to the lightning problem is to build lines which will prevent lightning strokes from ever getting on the transmission lines. The use of overhead ground wires and towers with low footing resistance were steps in this direction.

Investigations on over-voltages of transmission lines were described in a paper by C. L. Gilkeson and P. A. Jeanne. This paper described in detail observations of line and ground voltages under routine operating conditions on an isolated neutral system, a Peter-

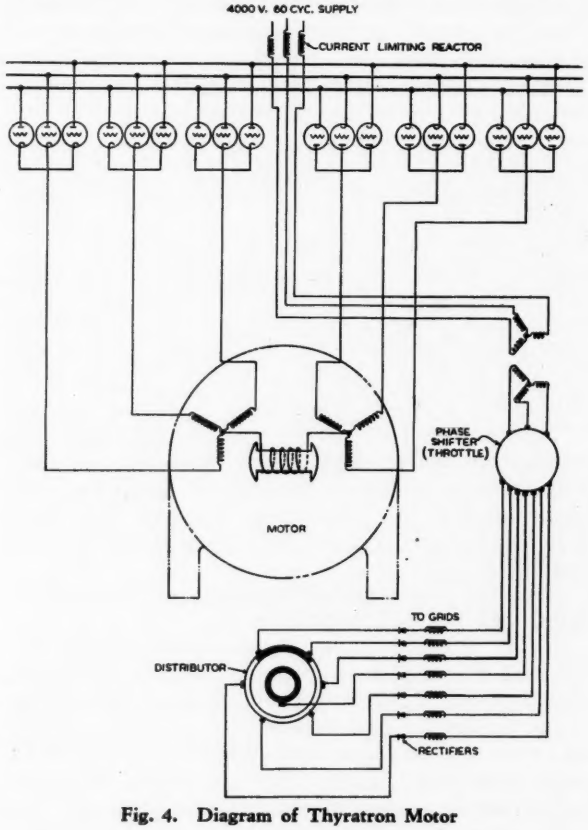


Fig. 4. Diagram of Thyratron Motor

son coil system, three neutral resistance grounded systems and two directly grounded systems.

The session on Illumination was of interest because of the variety of the luminants discussed. There were only three papers discussed at this session but they covered all forms of modern electrical illumination.

W. C. Kalb of the National Carbon Co. presented a very interesting paper on the characteristics and uses of the carbon arc.

The more modern forms of luminants, that is the gaseous discharge type, were discussed by Saul Dushman of the General Electric Co. in a paper on low pressure gaseous discharge lamps.

The third type of luminant, namely incandescent, received treatment by Samuel Hibben of the Westinghouse Lamp Co., in a paper entitled "Incandescence—Some Theoretical Aspects." Mr. Hibben showed that in spite of remarkable achievements in

luminescent illumination, the incandescent lamp still is believed to await a genuine challenge.

Electronics Symposium

Because of the wide application of the multielectrode tube at the present time it was appropriate to open the discussion of electronics with a paper on the Theory of Multielectrode tubes by H. A. Pidgeon of the Bell Telephone Laboratories. In this paper Mr. Pidgeon discussed the principles underlying the characteristics and performance of multielectrode vacuum tubes in comparatively simple terms. It gave those who were only familiar with the principles of the triode or 3 electrode tube an opportunity of understanding the more complex tubes now in use.

Cathode Ray tubes and their application was the subject of a paper by J. M. Stinchfield of the R. C. A. Radiotron Co. Mr. Stinchfield outlined the development of the present day thermionic type of cathode ray tube, from the early Brann tube.

A presentation of unusual value was that by J. W. Horton of Massachusetts Institute of Technology in his paper on Uses of Vacuum Tubes in Measurement. This paper was essentially a list—a comprehensive bibliography of literature on vacuum tubes. Some 600 references are included in this list, selected from a total of about 1500 papers or books published since 1920.

Another paper of great interest presented at the first session was one on Vacuum Tubes as High Frequency Oscillators by M. J. Kelly and A. L. Samuel, both of the Bell Telephone Laboratories. This presentation dealt with vacuum tubes as oscillators and amplifiers at frequencies greater than 100 megacycles. The results of the investigations in this field were of great interest. With the ordinary triode, it was shown that there is a direct relation between the power output and the frequency at which the tube operates.

Limits to Amplification were discussed in a paper by Johnson and Llewellyn of the Bell Telephone Laboratories. In this they pointed out that the amplification obtainable in a vacuum tube amplifier is limited by the noise in the circuit. Of the various sources of noise the most fundamental and inevitable is thermal agitation of electricity. The authors pointed out that modern amplifiers have reached such a stage of perfection that their noise levels often are practically at the natural limit.

The second session on electronics was devoted more to the specific application of electronic devices in industry. The first paper, by O. W. Pike and Dayton Ulrey of G. E. and Westinghouse respectively discussed the Ratings of Industrial Electronic Tubes. This was followed by two papers on the application of electron tubes; one, by Gulliksen and Stoddard of Westinghouse dealing specifically with control applications and the other by D. E. Chambers of General Electric on general industrial applications.

Without question the most interesting application of the vacuum tube was that described in the paper, "The Thyratron Motor" by Alexanderson and Mittag both of General Electric. This described a motor in which a scheme involving electron tubes is used to perform a function similar to that of a commutator. The motor operates at variable speed and is supplied from a three phase power system.

The final paper at this session was one by C. F. Wagner and L. R. Ludwig, both of Westinghouse, on the Ignitron Type of Inverter. Although a comparatively recent development, the Ignitron principle has already had a number of important applications and this particular device, although still in its experimental stages seems to have important future possibilities.

In the discussion of these papers on Electronics, it was pointed out by Mr. Strausburg of Cutler-Hammer that the increasing use of electronic devices makes necessary a need for a great deal better grade of plant electrician than we have at present.

As already stated the paper on the thyratron motor by Dr. Alexanderson was received with great interest. The motors described had a speed range of from 320 r.p.m. at which it developed 75 hp., to 620 r.p.m. with an output of 400 hp. Between these limits of speed there is only a 7 per cent variation in efficiency, the efficiency dropping from 90 per cent at 620 r.p.m. to 83 per cent at 320 r.p.m. The motor is similar to a conventional synchronous motor but it has the characteristics of a series d.c. motor.

Most interesting of the discussions was that by Philip Sporn, of the American Gas and Electric Co., for he announced that the 400 hp. described in the paper had been purchased by his company for use in one of their power stations in induced draft fan service. This, of course, was in the nature of an experiment but during the tests at Schenectady, the motor had been put through very stiff paces with excellent results. Loss of tubes, did not affect its operation; it had even been started on single phase power. The only question, of course, is that of tube life, and here Mr. Sporn pointed out that no tube progress can take place until tubes by the hundreds and thousands are put into use. The central station companies, he said, can do their part by cooperating with the manufacturers in trying out these new devices.

Dr. Willis, of Princeton University, referred to the highly desirable flexibility characteristics this motor had, not only with respect to speed control but as regards location. The motor can be located at any point and the control at another, with only comparatively simple connections between. A 100 per cent speed variation, he said, was obtained with no sacrifice of characteristics.

Mr. Ludwig of Westinghouse discussed the economic aspect, pointing out that at present the cost of the control apparatus was considerable and that no extensive application of this motor could be made.

George Southgate asked the authors about the possibilities of using this motor on low voltages 220-440 and in sizes from 1 to 20 hp. and Mr. Mittag in closing the discussion said that such voltages were rather too low and that motors from 1 to 50 hp. would be too small to take advantage of this system. Of course no one could tell what further development would bring but at present he thought the motor was applicable only to sizes over 50 hp. and of higher voltages than 440. Tubes were expensive at present, he agreed, but radio tubes which once sold for 5 and 6 dollars apiece now could be bought for 35 cents, so he was not dismayed by the present high tube costs.

Design Notes for A Water Cooling System

Typical Layouts and Calculations Employed in Design of Modern Drinking Water Systems. By R. B. Reagan

PROPERLY designed and intelligently installed cooled drinking water systems are growing in popularity day by day for the reason that they have proven a worthy investment as a measure of increased efficiency as well as safeguarding health of either the tenants or employes of any structure equipped with conveniently located fountains capable of serving clean, pure water at a temperature of 45 to 50 deg. F.

The modern drinking water system must not only serve cool and potable water free from germs or pipe sediment, but also must possess the ability to supply an adequate quantity of palatable water at a temperature which will permit drinking in sufficient quantities to allay thirst completely and at the same time not inflame or irritate the mouths or throats of those using it. Thus eliminating repetition of many failures common to numerous existing installations, such as—deliverance of water that is too hot or too cold, insufficient quantity of water due to lack of pressure, or the other alternative of receiving a veritable shower bath when in quest of only a few swallows.

Recently there have come into popular use individually operated mechanical cooler units, which, when properly regulated, meet with satisfaction for servicing small offices or shops but are inadequate and expensive when called upon to serve a large group of people. When drinking water systems are distributed over a considerable area, such as apartment houses, office buildings, hotels, industrial plants or department stores, the centrally located plant embracing a refrigeration machine, cooling tank and a recirculating distributing circuit having good insulation is best suited to supply the various founts through the structure.

Such a drinking water system should be planned with a thorough knowledge of all the conditions to be met; viz., the source, pressure and temperature of the water supply, the number of persons to be served, the nature of their occupations, locations of the fountains, floor elevations, area to be served and any other outstanding feature peculiar to the project, should each in turn receive thorough analysis and consideration. An item that is frequently overlooked is the rendering of the water supply clear and attractive, as water that is cloudy in appearance is more or less objectionable. This shortcoming can be overcome by filtering, using sand, charcoal or fabric to remove the foreign matter and air that may be held in suspension.

Figure 1 shows, in a general way, the simplest arrangements for a small system, served by a central plant, consisting of an open type cooling tank or interchanger located in an elevated position above the drinking fountains, to which the water runs by gravity and is known as an open system.

Where the city water pressure is high enough to deliver the water to the various fountains, Fig. 2, a similar installation may prove feasible, but a closed water cooler must be provided in place of the open type, as used in Fig. 1. Nevertheless, neither of these systems would prove very satisfactory in operation, their only asset being a cheap installation cost. They are not to be recommended, as it is necessary to waste several quarts of water before chilled water comes to the fountain.

A closed system, Fig. 3, is a preferable and more economical layout, provided with a pressure type water cooler, to which city water is connected directly. A circulating pump supplies the cooled water to the various founts. During periods when the tap water is sufficiently cold, the refrigerated cooler and circulating pump may be by-passed and the founts supplied direct with city water, provided, of course, the minimum city pressure is sufficient to supply the entire building. The pump simply has to overcome the velocity head, which is negligible.

For buildings of moderate height and where the system is rather extensive, an efficient and economical layout should incorporate both a circulating pump and an open type water cooler as may be noted in Fig. 4.

Figure 5 shows a typical system for a higher building than depicted by Fig. 4. It is provided with a pressure type water cooler and circulating pump. Where pressure losses are inevitable as in the higher type of structure, it is well to split the system, each section of approximately the same area or load, as indicated in Fig. 6, i.e., one unit serving one-half while the other unit provides for the remainder. In case there is an existing house tank at a higher level than the circulating system, then the closed purge tank could be replaced by a connection from that point to the house tank which would provide both the make-up water and the necessary air vent. Also, as the lower half of the upper system has no service connections, the water in both the supply and return risers balances, therefore, the load on the pumps required for circulation does not necessarily increase with the height of the building, but is determined

rather by the amount of friction which must be overcome in circulating the water within the system.

Likewise, in a multi-story building, it is desirable that the drinking fountains on the various floors should be located vertically, one above the other. Long dead ends and connections so made that they will trap air must be avoided, as the nuisance of having to run the warm water from an uncirculated connection, or getting an air blast through the fountain preceding or during the taking of a drink, is too common an annoyance and must be eliminated if the installer of these systems has any interest in his future business aspects. This failure can be avoided by the addition of a few feet of return piping, i.e., a completely closed system.

The number of shut-off valves should be limited for the sake of economy of installation, as the insulation

dental to metal working. From analysis it has been found that the water consumption will average one quart per man hour during peak hours.

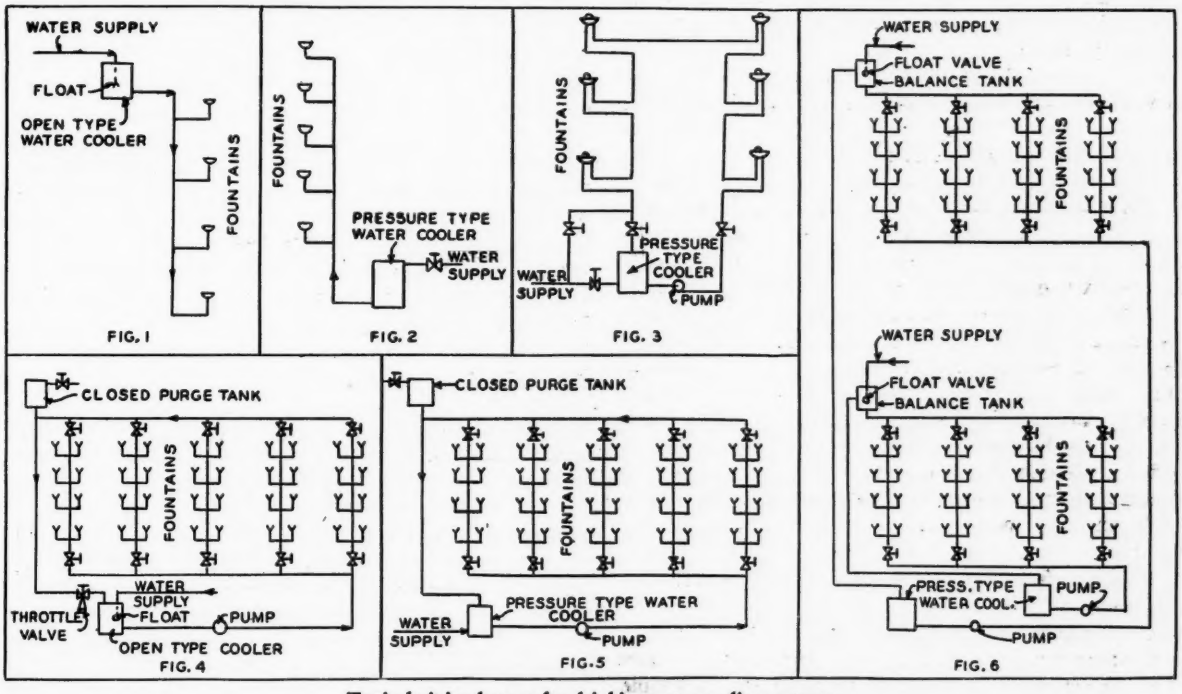
(b) That the total distribution system to the various drinking fountains will entail 2500 ft. of pipe.

(c) The average shop temperature during the peak season will amount to approximately 85 deg. F.

(d) The available water supply from the city mains averages 78 deg. F., and at a pressure of 50 lb.

(e) It is desired to supply drinking water to the various fountains at a temperature not exceeding 45 deg. F. and with an allowable temperature rise not to exceed 5 deg. F., through the system.

From this accumulation of data we determine the following deductions: That the circulating water will



Typical piping layouts for drinking water cooling systems

Fig. 1. Fountains fed by overhead open type cooler. Fig. 2. System employing pressure type cooler. Fig. 3. Simple circulating system. Fig. 4. Circulating system using open type cooler. Fig. 5. Pressure type cooler in multiple circuit system. Fig. 6. System suitable for tall buildings.

of such fittings is a rather conspicuous figure when summarized, whereas the only gain would be the elimination of entire shut-downs during times when repairs are necessary; that, of course, should be infrequent.

Cooling apparatus and circulating piping should be properly covered with cork insulation of ice water thickness or other material of equal insulating value.

Where a coil type water cooler is selected in lieu of a water heat interchanger, a means must be provided to promote agitation of the water in the tank, otherwise the water would not be evenly cooled and, upon any failure of the automatic control devices, a freeze-up would inevitably occur.

For sake of example, let us assume that we are to provide a cooled drinking water system for a typical manufacturing plant of the following characteristics:

(a) There are 350 workers exposed to heat incihave a mean average temperature of 47 to 50 deg. F. The difference between room and water temperature will be: 85 — 47.5 or 37.5 deg. F., and from a table of heat transfer coefficients we find that cork covering, ice water thickness for 1-in. pipe will entail a heat gain of 0.152 heat units per lineal foot per hour per degree difference of temperature.

With these factors available, we now solve for gallons per minute.

$$(1)\quad \frac{2500 \times 37.5 \times 0.152}{5 \times 62.5} = 53.60 \text{ cu. ft. per hour}$$

$$(2)\quad \frac{350}{4 \times 7.48} = 11.7 \text{ cu. ft. per hour}$$

Total..... 65.3 cu. ft. per hour

The total water estimated to be pumped to the fountains will, therefore equal:

$$(3)\quad \frac{65.3}{60} = 1.08 \text{ cu. ft. per min. Or,—}$$

$$1.08 \times 7.48 = 8.07 \text{ g.p.m.}$$

In the above calculations the quantities used have the following values:

2500 = Total length of pipe.
37.5 deg. = Temperature differential—air, water.
0.152 B.t.u. = Heat loss through insulation.
5 deg. = Possible water temperature rise.
62.5 = Pounds of water in one cu. ft.
60 = Minutes in one hour.
7.48 = Gal. of water per cu. ft.

To maintain the predetermined temperature in the circulating water line, we now calculate for the refrigeration tonnage:

$$(4)\quad \frac{2500 \times 37.5 \times 0.152}{12{,}000} = \ldots\ldots\ldots 1.39 \text{ tons}$$

To cool make-up water:

$$(5)\quad \frac{11.7 \times 62.5 \times (80 - 45)}{12{,}000} = \ldots\ldots 2.14 \text{ tons}$$

Total 3.53 tons

To offset mechanical heat of the motors:

(6) Add 6 per cent to calculated tonnage ..... 0.21 tons

To care for loss through cooler:

$$(7)\quad \frac{1.39 \times 45 \times 4}{288{,}000} = \ldots\ldots\ldots\ldots 0.09 \text{ tons}$$

To care for contingencies:

(8) Add 8 per cent to 10 per cent = .34 tons

Total refrigeration load required..... 4.17 tons

The quantities as above listed have the following values:

2500 ft. = Length of pipe
42.5 deg. = Temperature differential
0.152 B.t.u. = Heat loss by insulation per lineal ft. per deg. dif. per hr.
12,000 = One ton of refrigeration per hr. in B.t.u.
11.7 = Cu. ft. of water required (2)
62.5 = Pounds of water in one cu. ft.
80 deg. — 45 deg. = Difference in temperature of city and cooled water
1.39 = Tons of refrigeration to care for pipe losses
45 deg. = Circulating water temperature
4 qt. = One gal.
288,000 = One ton of refrigeration per 24 hr. in B.t.u.

The size of the recirculating pump to be selected is readily obtained, when the quantity in g.p.m. has been determined, to which data are added the total head in feet and the friction losses that the entire piping system imposes. Likewise, the horsepower is found by multiplying the gallons pumped per minute by the total lift and dividing the product by 4000.

Power required to drive the compressor will depend upon the suction and the condenser pressures maintained, and upon the type of compressor, whether single or double acting. With an ammonia system employing a simple, single acting compressor and maintaining a condensing pressure of 145 lb. per sq. in. and a 15 lb. suction or back pressure, there will be required about 1.2 hp. per ton refrigeration capacity or, for 4.2 tons, 5 hp.

In closing, the writer advises departure from the old habit of guessing and undersizing of the distribution piping. Piping that is too small results in high flow velocity and of course necessitates a relative increase of power consumption. Whereas, oversizing has the decided shortcoming of increasing the refrigeration demand.

Diesel Fuel Oil Classification

IN RESPONSE to requests from manufacturers and users of Diesel engines, petroleum refiners and distributors, A.S.T.M. Committee D-2 on petroleum products and lubricants was formed and has completed Diesel fuel oil classification to enable the differentiation of fuel oil types suitable for Diesel engines. The classifications shown in the accompanying table cover five grades of oil and is an attempt to supply this need. It is not the intention of the Committee that this classification should be used as purchase specifications but rather that fuel purchased be correlated according to the proposed classification in order to determine its usefulness.

Diesel-Fuel oil classified in five grades

Grade of Diesel Fuel		Flash Point, deg. Fahr.	Water and Sediment, per cent by volume	Viscosity, seconds			Carbon Residue, per cent by weight	Ash, per cent by weight	Pour Point, deg. Fahr.	Sulfur	Ignition Quality
				Saybolt Universal (at 100 F.)		Saybolt Furol (at 122 F.)					
		Min.[f]	Max.	Min.	Max.	Max.	Max.	Max.	Max.[h]		
No. 1-D[a]	A distillate oil for use in engines requiring a low-viscosity fuel	115 or legal	0 05	32	50	...	0 2	0 01	35	[i]	[j]
No. 3-D[b]	A distillate oil for use in engines requiring a medium-low-viscosity fuel	150	0 2	32	70	...	0 5	0 02	35	[i]	[j]
No. 4-D[c]	An oil for use in engines requiring a medium-low-viscosity fuel	150	0 6	..	500	...	3.0	0.04	35	[i]	[j]
No. 5-D[d]	An oil for use in engines permitting a medium-high-viscosity fuel	150	[g]	..	...	100	6 0	0.08	40	[i]	[j]
No. 6-D[e]	An oil for use in engines of special design for high-viscosity fuels and after engine manufacturers' recommendations only	150	[g]	..	...	300	10 0	0 12	40	[i]	[j]

[a] Grade No. 1-D is recommended for mechanical (solid)-injection engines of the high-speed type; in general, for engine speeds over 1000 r.p.m.

[b] Grade No. 3-D is recommended for mechanical (solid)-injection engines of the medium-speed type; in general, for engine speeds from 360 to 1000 r.p.m.

[c] Grade No. 4-D is recommended for air-injection engines, both two-and four-stroke cycle types, with speeds not over 400 r.p.m. Grade No. 4-D can be used for mechanical (solid)-injection engines with cylinder diameters over 16 in. and speed under 240 r.p.m., but approved heating equipment furnished by the engine manufacturer is recommended.

[d] Grade No. 5-D is recommended for air-injection engines of the slow-speed type; speed under 240 r.p.m. Manufacturer should be consulted for approved heating equipment.

[e] Grade No. 6-D is not regularly used for Diesel engines and is not recommended unless tested and approved by engine manufacturer. The purchaser should be informed regarding high maintenance cost of engines and operating problems involved in the use of this grade of fuel.

[f] Minimum flash point as stated or as required by local fire regulations, Fire Underwriters or state laws.

[g] To be inserted later.

[h] Lower pour points may be specified whenever required by local temperature conditions to facilitate storage and use, although it should not be necessary to specify a pour point of less than 0 F.

[i] So far as known, sulfur content need not be considered as regards combustion characteristics. However, a maximum of 2 per cent is suggested to purchasers operating engines in intermittent service, to limit corrosion.

[j] See discussion under Methods of Testing, Paragraph (g) Ignition Quality.

As One Engineer to Another—

G. F. Discusses Factor of Evaporation and Boiler Horsepower

By G. F. WETZEL, M. E.

RRRRING. As the final clear bell tones of the telephone died away I picked up the receiver and a familiar voice said, "Hello, is G. F. there?" "Hello, yourself, Chief," I answered, "This is G. F. speaking, and how is every little thing?" "Pretty good, G. F., except that I haven't had the pleasure of a call from you for quite a while, and wondered if you were unusually busy, or had forgotten your friend, the well known chief operating engineer of the ———— Company." "I have been pretty busy, Chief, but had planned on dropping in on you this afternoon," I told him. "That is fine, G. F., I'll be looking for you. So-long," and a click told me he had hung up the receiver.

I felt quite sure that something was on his mind more than casual conversation and looked forward to our meeting with curious anticipation. I have learned much from talking and working with the practical operating men I know, and have come to get a pretty good understanding of their viewpoints and mental attitudes, so that I always enjoy my contacts with them, particularly my friend the Chief.

Toward the middle of the afternoon, I started for the plant where the Chief holds forth. When I reached his office, I saw him going over some memoranda with such concentration that he did not hear me until I drew up a chair and sat down near him. After his usual friendly greeting and discussion of the weather and things in general, he said, pointing to the papers on his desk, "Remember that lad who was here talking to the Boss. Well, he was around again yesterday and was asking about our steam pressure, evaporation, boiler feed temperature, and per cent of rating we are running at. He said he wanted to get our equivalent evaporation, and give the Boss a more detailed proposal. I just told him I couldn't give out any information without authority from the office, and though he didn't like being turned down he could not do anything about it. I knew the Boss was out of town for a week so he could not get in touch with him until I had a chance to talk to you and work out my own report."

"Well, Chief," I said, "I thought you just wanted to visit with me for my own sweet self, and now I find you have an ax to grind. But remember you never get anything for nothing. I suppose you want to talk about Equivalent Evaporation and Boiler Horsepower."

"That's about it, G. F.," the Chief answered. "You see we got a pretty good start last time and you've gotten me interested in going into this steam stuff more thoroughly, especially since I have the chance to use it."

"All right, Chief, let's see what your equivalent evaporation would be. It is only the evaporation per pound of coal that you would get if you were making steam at a temperature of 212 deg. and pressure of 14.7 lb. per sq. in. absolute, from feedwater at 212 deg. In other words, it is the evaporation *from and at* 212 deg."

"I have a faint recollection of having heard that before," interjected my friend, "but I am hazy on how to apply it. I suppose I'm like most of the fellows who get away from the theory side of engineering. I think I know this stuff until I try to apply it; then I must admit I'm not as smart as I thought I was."

"Chief," I told him seriously, "those are honestly smart words, because when a person is in a receptive mood, and interested, knowledge comes much more easily. To continue, I suppose you want to know how to find the equivalent evaporation. It is done simply by finding and using the Factor of Evaporation. This factor is nothing but a ratio; that is, the ratio of the heat in one pound of steam above that at feedwater temperature compared to the heat required to evaporate one pound of water from and at 212 deg. You will recall that when we talked about boiler efficiency we found that it was a ratio—the ratio of output to input. The output was the number of pounds of steam per pound of coal, multiplied by the heat added aboye feedwater temperature per pound of steam, which gave us a heat quantity expressed in B.t.u. The heat added above feedwater temperature was put down in the notes you kept, and you will remember it was

$$(H_1 — q_2)$$

H_1 being the total heat in the steam (above freezing point) and q_2 being the heat of the liquid of the feed (also above 32 deg.). Give me the figures."

The Chief looked over his notes and gave me this:—

$$(H_1 - q_2) = (1195.0 - 127.9) = 1064.1 \text{ B.t.u.}$$

"This quantity," I continued, "is the net amount of heat added to each pound of steam by the boiler. The net amount added making steam from and at 212 degrees would be only the latent heat of evaporation at 212 deg. F. or 970.4 B.t.u. per pound. You can readily see why this is true; the water being already at 212 deg. requires no additional heat to bring it to the boiling point, so no heat of the liquid is to be added by the boiler in this case. Therefore, with the condition 'from and at 212 deg.' the only heat quantity involved is the heat required to change the state of

the water from liquid to vapor. This figure of 970.4 is one that you should remember, as it is often used in figuring steam problems. I hope you realize that the boiler, under your plant conditions with feedwater at 160 deg., and pressure 150 lb. gage, not only evaporates the water but has to raise its temperature from 160 to the boiling point of 366 deg., or an increase of 206 deg. It adds the difference between the heat of the liquid of the feedwater at 160 deg., 127.9 B.t.u., and the heat of the liquid of the steam at 150 lb. pressure, 338.2 B.t.u., the difference being 210.3 B.t.u. which is included in the figure of 1064.1 B.t.u.

"Now to get the ratio we spoke of, or the Factor of Evaporation, we just divide (1195.0 — 127.9) by 970.4, or 1064.1 ÷ 970.4 = 1.097. Therefore your factor of evaporation is 1.097.

"To use it, you simply multiply your evaporation under actual conditions by this factor and the result will be the number of pounds of steam you would have evaporated if your feedwater temperature had been 212 deg. and your steam at temperature of 212 deg. also, with atmospheric pressure, 14.7 lb. per sq. in. absolute. Let's see,—what was your evaporation, Chief?"

"We figured it at 7.3 lb. last time," he told me.

"Well, then, your equivalent evaporation will be 7.3 × 1.097 = 8.008 lb.," I replied after some quick figuring. "Nothing hard about that, is there, Chief?"

"A six tumbler Yale lock isn't hard to open either," the Chief came back at me, "if—if you have the right key! I notice," he continued, "that the factor is a little greater than one. Is that always the case?"

"When you can answer your own questions, Chief," I suggested, "the answer will stick with you longer than if you have it handed to you, and many times the process of getting the answer will bring out useful information, besides giving you the satisfaction of doing it yourself. We will take several different conditions and see what we get. If the heat added per pound of steam is less than 970.4 the factor will be less than one, and if more, the factor will be more than one. A table something like this will be a good way of working it out:

Line	Temp. Feed-water	Steam Pres. (abs.)	Steam Temp.	H_1	q_2	Net Heat Added	Factor of Evap.
1	160	10					
2	150	20					
3	180	65					
4	200	215					
5	110	250					
6	250	500	600				

"There are several figures there that need your attention before you fill in the other columns. What about 10 lb. absolute, pressure?"

"That is 4.7 lb. below atmospheric pressure, or about 10 in. of vacuum," the Chief replied, after thinking a moment.

"That's good, Chief," I said. "And now what will keep line No. 6 feedwater at temperature of 250 deg. from flashing into steam; because water boils at 212 deg.?"

The Chief realized that he was on the spot to a certain extent, and wasn't quite sure how to answer, so he asked a question himself,—"Would the pressure have anything to do with it?"

"Let us look at the steam tables and see what pressure corresponds to 250 deg. steam temperature," I suggested. He accordingly looked and told me it was 29.82 lb. absolute, or 15.12 lb. gage. He added, "I suppose then, that at any pressure above 15 lb. gage the feedwater at 250 deg. will not turn into steam. Is that right?"

"Okay, Chief,—I see that your memory is still working after a fashion, and that there is hope for your reasoning powers. Now tell me what No. 6 steam temperature suggests to your fertile imagination."

"Wait until I look in the book," returned the Chief, opening his book at the steam tables, and getting the saturation temperature at 500 lb. "466.99 deg.," he read off, and looked at the table we were in the process of constructing. "Didn't you make a mistake, G. F., putting down 600 deg., when it should be about 467 deg.? Sort of over-heated, isn't it?"

"Chalk up another good mark on your progress chart, Chief," I said, "That is exactly what it is,—superheated steam!"

"But I said over-heated," he objected.

"Well," I returned, "What difference does 'over' or 'super' make between friends,—in this case they mean the same thing."

He let that soak in for a minute, then,—"That's one for your side, G. F. You know, as long as I have been working around steam equipment, and hearing and reading about steam, I never heard superheated steam called 'over-heated,'—but that is really all it is when you stop and think about it."

"How much superheat would there be with No. 6 conditions?"

"Frankly, G. F., I don't remember quite how to get it," he said somewhat hesitantly.

"Well, considering it as overheated steam, wouldn't it be just the number of degrees between saturation temperature of 466.99 deg., or call it 467, and 600 deg., amounting to 133 deg. of superheat?"

The next thing, Chief, is for you to do a little work while I look over the morning paper. Use your steam tables again and fill out the rest of the table. There are five columns patiently waiting to have their figures put in place. Subtract q_2 from H_1 in each case to get the 'Net Heat Added,'—then divide that by 970.4 for each value to get 'Factor of Evaporation.' Remember to use the Superheat Table for No. 6. Go to it!"

After twenty minutes or so, he showed me the completed table as follows:

Line	Temp. Feed-water	Steam Pres. (abs.)	Steam Temp. (Deg.)	H_1	q_2	Net Heat Added	Factor of Evap.
1	160	10	193.21	1143.0	127.85	1015.15	1.046
2	150	20	227.96	1156.0	117.84	1038.16	1.069
3	180	70	302.92	1179.9	147.87	1032.03	1.063
4	200	200	381.82	1197.8	167.94	1029.86	1.061
5	110	250	400.97	1200.5	77.89	1122.61	1.157
6	250	500	600.00	1297.3	218.39	1078.91	1.112

"That looks alright, Chief. Suppose we go over it and you tell me what you see." So we placed the above table of figures on his desk so we could both

see it, and after looking it over again himself, the Chief said, "Well, for one thing, none of those Factors are less than one, though I can see that it is possible that they might be, if the feedwater was hot enough. Another thing I see is that the temperature of the feedwater has an important effect on the Factor. Number 5 with a low temperature has an even higher factor than the superheated steam factor, No. 6. But then No. 6 feed temperature is high. Also Nos. 2, 3, and 4, which are more in line with average conditions, have a very similar factor, which might lead me to guess that as long as the feedwater temperature goes up about in proportion to the steam temperature and pressure, the Factor will not change much."

"Very good," I told him. "Those are the important points I wanted you to get. Now that you know all about equivalent evaporation, tell me what will be your equivalent per pound of combustible fired. You remember you figured your actual evaporation on that basis last time I was here."

"That's easy this time," he returned, anxious to use what he had reviewed. "Six per cent moisture and 9 per cent ash leaves 0.85 of a pound of combustible. A whole pound would do 100/85 as much." Picking up his pencil, he wrote on his scratch pad, and showed it to me:

Evaporation (equivalent) per pound of combustible $= 100/85 \times$ actual evaporation $\times$ factor of evaporation $= 100/85 \times 7.3 \times 1.097 = (7.3 \times 1.097) \div 0.85 = 9.42$ lb.

"Congratulations!" I exclaimed. "I certainly am glad to see how well you put that down. It is all there in such a way that, if you look at it a year from now, it will still tell you its story. Remember, every time you work out a problem, even a simple one, put it down completely, step by step. It is a fine way to minimize errors, and gives you something to check by, as you go along. One of these days I'll give some practice in working out and analyzing problems that you will appreciate. What else was it we were going into?"

"Boiler horsepower, G. F.," he reminded me. "Our boilers are rated at 300 hp."

"I don't know how much you remember about it," I began, "but we'll assume it is nothing, and play safe. So if I tell you something you already know, just listen anyhow, because part of it will be worth listening to at any rate."

"Boilers are rated on the basis of one boiler horsepower for each 10 sq. ft. of heating surface, except in the case of the Scotch marine type which usually allows 8 sq. ft. This is more or less an arbitrary method of rating boilers because with our present wide variations in operating temperature and pressure conditions 10 sq. ft. may generate much more or less steam than will be equivalent to a developed boiler horsepower."

"One developed horsepower is really a measure of the heat output of the boiler. It is defined as 34.5 lb. of water evaporated into steam from and at 212 deg. Since the heat per lb. from and at 212 deg. is 970.4 B.t.u., a developed Boiler Horsepower may also be defined as 970.4×34.5 or 33,479 B.t.u., a definite heat quantity."

"That seems to be simple enough," commented the Chief, "but once more I don't see just how to apply it. The value of knowing this steam and heat stuff is only in applying it, and that is the hardest part. Let's work out a problem or two. Here are our steam flow charts for the last few days," and he handed them to me.

"I see you average about 40,000 lb. per hour from your three boilers. For purposes of illustration suppose we say that boiler No. 1 generates 14,000 lb. per hour. To find the developed boiler horsepower, we can either convert the actual evaporation into equivalent evaporation in pounds, and divide by 34.5, or find the heat output in B.t.u. and divide by 33,479. Remember that the heat output is merely the number of pounds actually evaporated per hour multiplied by the value $(H_1 - q_2)$ or heat added per pound. It is only a matter of convenience as to which method you use, depending on what you have to start with. We already, in this case, have our factor of evaporation, so the b. hp. (boiler horsepower) is the actual total evaporation from No. 1 boiler multiplied by the evaporation factor and divided by 34.5. Here it is," I said, handing him this equation:

$$\text{B.Hp.} = (14{,}000 \times 1.097) \div 34.5.$$

"Figure it out!"

After a few minutes he told me the result was 445.2 hp.

"Now let's figure it the other way," I suggested. "That will simply be your evaporation multiplied by the heat added per pound of steam by the boiler, divided by the number of heat units in a developed boiler horsepower. In formula form it would look like this:

$$\text{B.Hp.} = [W_t \times (H_1 - q_2)] \div 33{,}479 = (14{,}000 \times 1064.1) \div 33{,}479 = 445.2 \text{ b. hp.}$$

In this W_t = total actual weight of water evaporated, lb. per hr.

H_1 = total heat per pound at observed pressure, B.t.u.

q_2 = heat in the feedwater, B.t.u.

I explained as I jotted it down and showed it to him. "To get percent of rating you once more get a ratio—this time ratio of developed boiler horsepower to rated horsepower. Putting it in figures, it is $(445.2 \times 100) \div 300 = 148.2$ per cent. You will notice that there are a lot of ratios that come up in this work. Once more I say, Simple, isn't it?"

"Thanks, G. F.," the Chief said. "I really believe, if I get the fundamentals down, I will be able to figure out a lot of interesting things. I sort of let myself get scared of the theory end of it, but it all seems logical and reasonable when you get into it."

"I certainly am glad to hear you say that, Chief," I answered, sincerely, "because if you are not afraid of giving your mental equipment a little exercise, you can get yourself into a position where you will welcome the problems that come to you, will have a lot more respect for yourself, and more justifiable confidence in your own ability. Furthermore, I have seen it work out so many times that I firmly believe that opportunities for advancement come to us in just about the proportion that we are equipped to take advantage of them."

Automatic Regulation—

A Rapidly Changing Art

Progress in the Art of Control Demands New Standards by Which the Performance of Modern Regulating Equipment Must Be Judged. By A. J. Boynton, H. A. Brassert & Co., Chicago, Ill.

RAPID PRESENT DAY PROGRESS in pure science, and in its application to processing and to mechanical design, requires that operations as well as machines shall be able to meet specifications which would have been impossible of fulfillment a few years ago. These changes, important in their effect on many phases of industry, have materially changed the demands on automatic regulating equipment. These changes are of two kinds. The mechanical design of the instrument must be better than formerly, to providing greater accuracy and practical freedom from interruption. A wider application is also necessary. In consequence, problems of regulation are now being regularly solved which are interesting because of their complicated nature and of the number of forces which must be brought into constant relationship by means of the control. These companion avenues of progress are worthy of review.

With regard to the regulating unit itself, there is an evident trend away from the older and nominally simpler means of operating a valve by direct application of the pressure which it controls. This tendency follows the discovery that apparent simplicity in design is accompanied by very real complications in operation. The use of a regulating unit is becoming practically universal, but the standards to which such a regulating unit should be able to conform are as yet confused in the minds not only of many purchasers but of some designers and suppliers. These standards may be defined in part as follows:

First. The regulator should be adapted to provide metered regulation as distinguished from position regulation. In order to do this conveniently and economically, it should be capable of producing two opposing regulating forces, which may be applied to either side of a regulating piston. In this respect it is to be distinguished from those regulators which are capable of producing one regulating force only, which force is opposed by a spring or other device, as in an ordinary spring operated diaphragm valve. It is also essential that these opposing forces shall vary in accordance with the tendency to depart from equilibrium, so that a small departure produces a small correcting force while a surge produces a maximum regulating action. The regulating forces must be adequate for any weight of damper or valve.

Second. The regulator should be so designed that no "stabilizer" or "compensator" is necessary, excepting on account of lag in the regulated system. This is to say that when a movement of a regulating valve produces a prompt change in the pressure acting on the regulator, compensation should be unnecessary.

Third. The second condition requires that the moving parts should be light and their movement small, so as to avoid inertia. Friction must be reduced to the minimum. Good design also requires that the regulating forces shall be completely independent of gravity. That is, there should be no weight of regulator parts acting with or against the regulating forces. It is also necessary that the means by which the outgoing regulating force is created, as oil, air, water or electric current, shall not react on the incoming forces of pressure which determine the action of the regulator.

Fourth. Means of stabilization should exist for the regulation of systems which have a pronounced lag, such as those including heavy flywheels or gradual changes of temperature. These stabilizing means should not require a change in the value of the regulated quantity.

Fifth. For the full application of automatic regulation, it is desirable that a maximum number of forces may act on the regulator. Many problems require opposition of two sets of forces, as in ratio regulation,

while the intervention of a third set, which may change the ratio automatically or manually, is often essential.

The Askania jet pipe regulator was developed to meet these conditions and is manufactured by the American Askania Corp. of Chicago. Figure 1 shows an application as a constant pressure regulator and the photograph of a cut-away model in the illustration at the head of this article shows the construction. Figure 2 shows an application as a ratio control and it will be apparent from the illustrations that the means of regulation is oil or air, forced through the jet pipe under pressure and projected from the jet pipe nozzle against

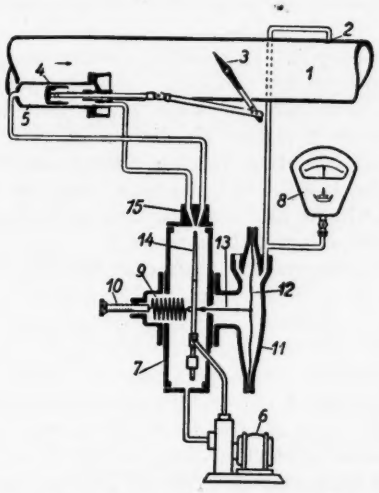


Fig. 1. The Askania jet pipe regulator as installed for pressure regulation. 1, gas main. 2, tap and piping to the indicating gage and to the regulator. 3, regulating butterfly-valve. 4, piston. 5, regulating cylinder. 6, motor driven oil pump. 7, regulating gear. 8, indicating gage. 9, helical adjusting spring. 10, adjusting slider. 11, casing for diaphragm. 12, diaphragm. 13, push-pin. 14, jet-pipe. 15, distributor

the orifice block of the regulator. Where oil is used, the pump pressure is a maximum of 90 lb. per sq. in. This is transformed to kinetic energy as it issues from the jet but is again transformed to static pressure in the pipes leading to the regulating cylinder. Excess oil not entering these pipes is drained away and returns to the pump. The jet operation is continuous and where equilibrium is maintained is only a means of keeping up the pressures on the piston. Where changed conditions require a movement of the piston, oil enters one orifice and is forced out of the other. This follows a movement of the jet pipe to right or left in accordance with the balance of forces acting on the pipe.

It may be seen from the figures that the regulator body, which carries the jet pipe, is designed to receive and hold, by four interchangeable bolts on either side, any impulse system, as for example the diaphragm casing shown, or the spring system used for regulating constant pressure, or any of several other systems designed to transmit to the jet pipe a force derived from operations which exhibit a great variety of static and differential pressure. For example, one of these constructions, the mercury balance, which may replace the diaphragm, is used for two static pressures up to 2000 lb. with a differential between them of only a 6 in. water column. Another system changes millivoltage into pressure on the jet pipe and regulates temperature.

It may be noted from the figures how completely the jet pipe assembly conforms to the requirements of a good regulator as above stated. The jet support is held in upper and lower bearings, practically frictionless. The weight of the jet pipe and its supports is 0.5 oz., the maximum movement is about 0.15 in. The reaction of the oil flow is at right angles to the incoming forces. The push pins bearing on the jet pipe are free of all weight of diaphragm or other mechanical parts. The regulating action is double, and is comparatively free from dependence on valve characteristics excepting that of size. Any valve, balanced or not, will be put in the correct regulating position by an Askania cylinder and this without hunting or over-regulation. Action is instantaneous.

The usual orifice block may be replaced by a small hydraulic stabilizing cylinder which compensates for lag, without charging the regulated value. An auxiliary piston for large forces is also available, and the stabilizer and auxiliary piston may be used together. The regulator shown in Fig. 2 is designed for three sets of forces, one on either side and one operating through the ratio slider. These forces are employed to produce a stabilized regulation in cases such as combustion, where a force corresponding to a function of fuel flow is balanced against a second force corresponding to the same function of combustion air flow, while a force corresponding to content of CO_2 in the waste gases determines the ratio between the first two sets of forces.

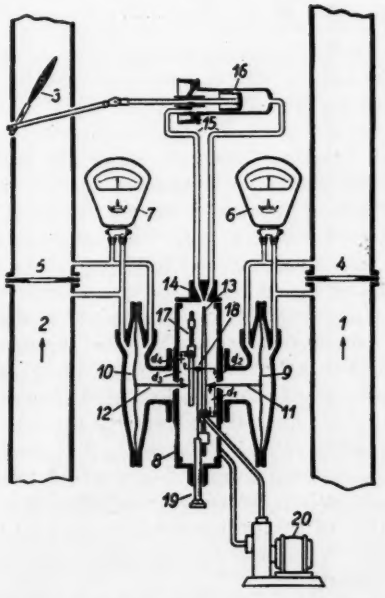


Fig. 2. Jet-pipe ratio control for the mixing of two gases. 1, main with gas I. 2, main with gas II. 3, regulating valve. 4, orifice plate. 5, orifice plate. 6, gage, indicating the flow of gas I. 7, gage, indicating the flow of gas II. 8, regulator. 9, diaphragm. 10, diaphragm. 11, push-pin. 12, push-pin. 13, the jet-pipe. 14, distributor. 15, oil-pressure piping. 16, piston in the regulating cylinder. 17, counter-lever. 18, ratio adjusting disk. 19, ratio adjusting-slider. 20, motor driven oil pump

Case Studies in Power Economics

Conducted By
ZUCE KOGAN
Kogan Industrial Service
Chicago, Illinois

Correction of Meter Needle Position

METER NEEDLES when not properly set before put into service frequently cause controveries, but seldom do such controversies involve such an amount of money as did the case which is related here.

A theater company made arrangements with a building adjacent to one of its theaters to supply steam for heating purposes. To measure the steam consumption, a condensate meter was installed and all the accumulated condensate from the radiators was measured. The arrangement was that the theater company pay a flat rate of $1 per thousand pounds of steam condensed.

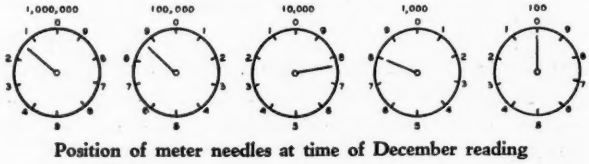
The theater began to purchase the steam in April, 1928, and bills were rendered thereafter the same day the meter was read at the end of the month. The consumption and bills rendered during the year of 1928 were as follows:

April, 90,000 lb.	$90.00
May, 58,000 lb.	58.00
Sept., 40,000 lb.	40.00
Oct., 70,000 lb.	70.00
Nov., 240,000 lb.	240.00

The foregoing amounts of steam seemed to be quite reasonable, as the theater seated around 500 and the steam consumption and the bills were in line with that estimated by the heating engineer. They were very much startled, however, when the bill for the month of December was rendered at the end of the month. The reading showed a consumption of 1,380,000 lb. of steam for which they were charged $1,380.00. This was all out of line with the previous readings. The month of December was comparatively mild and nobody anticipated such a vast amount of steam to be consumed during this month. The engineer of the theater immediately went down to check the meter, and, on account of the fact that the bill was rendered on the same day that the meter was read, he found it to all appearances to be correct.

Even theft of steam was suspected. A quick glance at the installation, however, precluded this thought. Examination of the equipment also indicated no leakage or any disarrangement which would cause the waste of steam.

Not being able to solve this puzzling problem themselves, the Chicago management called the writer and associates in to look over the job. On the third day after the meter was read, we looked over the meter, first for the possibilities of theft, then for leaks. We did not find any leakage or loss of steam, but in making the reading on the meter, which was 1,916,000, the position of the "million" needle was somewhat puzzling, as it was not in the exact place where one would expect it to be. We discounted this, however, and looked for other trouble. Being unable to find any, we checked the bill and found that the last reading was 1,878,000 and that previous to the last reading was 498,000. Hence, the apparent steam consumption for that month was the difference between these two readings, or 1,380,000 pounds. The difference between the present reading, 1,916,000, and the last reading, was 38,000 and that represented a quantity of steam consumed for the three days after the meter was read. Since those days represented a temperature similar to the preceding month, multiplying rapidly, we became reasonably certain that the steam consumption could not have exceeded 400,000 lb. for the previous month. In other words, there was a discrepancy of 1,000,000 lb. The position of the "million" needle of the meter came immediately back to our minds, and we made a more thorough study, and this is what we found.



Position of meter needles at time of December reading

The accompanying sketch shows the final position of the reading. You will note that the needle on the "million" dial was less than half way between one and two, whereas the reading on the "hundred thousand" dial showed nearly 9. That meant that the "million" dial needle, if it were in correct adjustment, should have covered 0.9 distance between one and two instead of only about 0.4 as was indicated. Taking this fact into consideration, we immediately perceived that there must have been a discrepancy between the setting of the "million" dial needle of about one-half division, and looking over the records from the time this meter was installed, we found the following: In April when they consumed 90,000 lb. of steam, the needle on the "million" dial should have moved only 0.09 of one division; second, in May when they consumed another 58,000 lb. of steam, the needle should have been at 0.148 of the first division on the "million" dial. In September, with a consumption of 40,000 lb. the reading was 188,000 and the "million" dial reading apparently showed 0.688 of the first divi-

sion instead of 0.188 as it should have been. In October the actual reading showed 70,000 over the previous reading and the "million" dial apparently showed three-quarters of a division. The addition of the November reading apparently brought the "million" dial needle to 0.998 or almost one, although it should have been five points less or 0.498. In December, however, with the addition of 380,000 lb. of steam the "million" dial needle was past 1, whereas the other needle showed 878,000. This reasoning has been recast into table form which may make the situation easier to perceive.

Month	Steam Used, Lb.	Meter Reading	Calculated correct position of million dial needle	Actual position of million dial needle calculated from December reading
Apr. ...	90,000	90,000	0.09	0.59
May ...	58,000	148,000	0.148	0.648
Sept. ..	40,000	188,000	0.188	0.688
Oct. ...	70,000	258,000	0.258	0.758
Nov. ..	240,000	498,000	0.498	0.998
Dec. ...	1,380,000*	1,878,000*	0.878	1.380*
Dec. Revised.	380,000	878,000	0.878	

This sounded rather plausible to the management of the theater. The manager of the building, however, would not accept the idea and he claimed there must have been some leakage of steam for which he was entitled to be paid. In order to settle the argument, we had a photographer take a photograph of the meter as it was and had the photographs enlarged. From these photographs, we reconstructed the reading of the meters as we thought they appeared in the preceding months, and with a series of markings on the photographs, we finally convinced the manager of the building that the original setting of the "million" dial needle was not at zero, but it was half way between the zero and one. A meter expert was called in by the building management to corroborate our statement and a refund of $1000 was made.

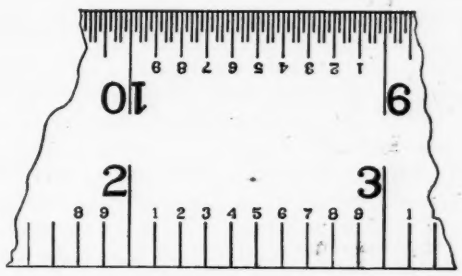
Of course, this sounds very simple, and one might say that anyone accustomed to reading meters could notice the error immediately. As strange as this may seem, however, the needles of a meter are seldom as correct as they should be and their position is generally not scrutinized very thoroughly. As long as a person sees the needle past a number he naturally reads it and thus the error creeps in. It was only after making the detailed needle positions on the enlarged photographs of the meter and explaining the situation that the thing could be clearly seen. By making this sketch and finding out the discrepancy of the needle, we caused a refund of $1000 for the month and also relieved the manager of the theater of a great deal of worry about the heating system.

We are tempted here to say that if this matter were left to run, this error would have shown up in the subsequent month. If, for instance, during the next month there were a similar steam consumption of 380,000 lb. the reading would have shown 1,258,000, that is, the needle of the "million" dial would have been at about three-fourths of the second division of the scale, but still one, and the "hundred thousand" needle would have shown 2, the "ten thousand" would have shown 5 and the "thousand" 8. This, of course, would have pointed out immediately there is something wrong. The manager of the building, however, would possibly have accused the manager of the theater with tampering with the meter in view of the fact that the subsequent reading was less than the previous reading. By pointing out the error right at the start, this condition was eliminated, the error mitigated and the saving on the incorrect reading made.

*Readings which caused controversy.

Decimal Dimensioning

FOR BASIC DIMENSIONING it is reported, in Industrial Standardization, that the Ford Motor Co. has adopted the decimal system so as to simplify the work of draftsmen, tool designers, tool makers and inspectors. This is the first departure along these lines for a major private corporation, although the United States Army Ordinance Department works on the decimal basis. The adoption of this scale provides some of the advantages claimed for the metric



Enlarged section of decimal system scale adopted by Ford. The finer divisions are fiftieths and the marks for the second and third fifth are longer than are the first and fourth so as to improve the readability

system without presenting the objections raised by American manufacturers against the general use of the metric system.

For easy application new scales have been developed and common fractions replaced by calibrations in tenths and fiftieths of an inch, the latter having been found more practical than 1/100ths due to better visibility and readability. Use of fiftieths or multiples thereof also compels every dimension requiring accuracy to end in an even number. This is a definite advantage since dimensions equally spaced from center lines are always divisible by two without involving the addition of an extra decimal point.

At present in the Ford plant the new scale applies to all parts except bores requiring the use of standard size reams, etc., and dimensions on the Ford drawings are gradually being changed over to the new system. It is reported that one or two tap die manufacturers are already considering the production of tools to decimal bases and if this work is developed a complete conversion of dimensioning to the decimal system could be effected.

Readers' Conference

Combustion on Chain Grate Stokers

We Must Agree with Mr. Darnell when he states in the December issue, pages 606-607, that the abstract of the article "Combustion Conditions on Chain Grate Stokers" given in your October issue, pages 482-483, was perhaps unsatisfactory in that space demands made it necessary to omit proof of some of the more important points of the original paper. We are gratified, however, that he took the trouble to examine the complete paper as published in Engineering of London May 25, June 8 and July 25.

Mr. Darnell has, however, failed to interpret the original article correctly. He rightly assumes that the first phase of the investigation is a study of the progress of combustion from the feed gate to the ash pit. The second phase is primarily a study of maximum temperature attained by the stoker links, and not a study of the temperature difference between the stoker links and the preheated air beneath, although this factor is used as a basis for the conclusions. The first phase of the investigation is merely intended to show the principle that green coal exists in contact with the grate for approximately 50-70 per cent of the length of the fire, a fact which, it was felt, was not previously realized.

This fact is confirmed by the curves, given in the second phase, which show that the temperatures of the links reach a maximum at a point approximately 60 per cent of the length of the fire where ignition has penetrated the fuel bed and the grate surface is exposed to its radiation. It is therefore contended that the principle shown in the first phase applies to all traveling grate stokers, whether natural or forced draft. It is admitted that the details as to the percentage of the grate in contact with green fuel and the shape of the fuel bed will vary to a certain extent with different coals, with different types of stokers and with different burning rates.

If Mr. Darnell is still unconvinced, a study of ignition and burning rates of fuels given in an excellent article by P. Nicholls and M. G. Eilers in "Combustion," June-July, page 15, would be to his advantage. Further evidence to support this will be found in a paper by Dr. E. S. Grumell, "The Evaluation of Fuel from the Consumer's Viewpoint," Journal of Institute of Fuel No. 24, Volume No. 5.

In this paper curves are given showing temperatures at various depth in the fuel bed on a forced draft traveling grate stoker in normal work which confirm in every respect the contention that green coal exists at a distance of approximately 50-70 per cent of the length of the fire from the feed gate. It is unfortunate that the halftone reproductions of the photograph of the fuel bed (shown as Fig. 1 of the original article) fails to show the detail in the negative which shows clearly the tapering layer of green fuel, followed by the red hot grid.

If the definition of "tempered" is the addition of moisture to the fuel, it should be noted that all fuels used during all experiments in both the first and second phase were "tempered" by the addition of approximately 5 per cent moisture added some 24 hr. before it was burnt on the stokers. This is such general practice that it was considered of too minor importance to mention.

Mr. Darnell has evidently interpreted the word "cauliflowering" in a different manner to that intended. We take it that he is referring to the swelling of the coal in Fig. 1 (reproduced from Fig. 1, p. 482, October issue, and p. 606, December issue) at a point 7 ft. from the feed gate. It is, of course, well known that the swelling properties of fuels vary enormously and it is not maintained that such a shape

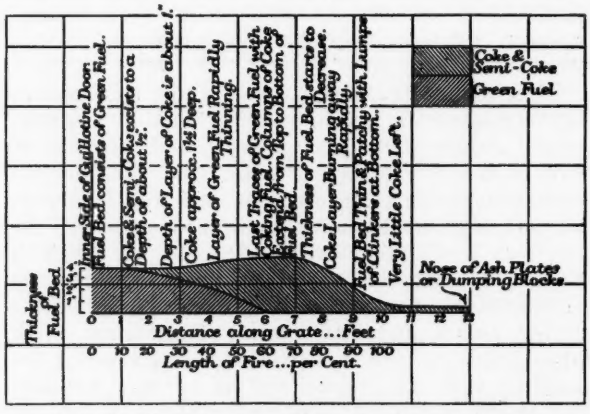


Fig. 1. Example of a section through the fuel bed

of fuel would be found with a free-burning fuel. Since the fuel was actually tempered, we cannot agree with his statement that, by adding 3 per cent moisture, such a swelling effect will be obviated with every type of fuel.

It must be remembered that Fig. 1 is plotted on two different scales and therefore appears more distorted than is actually the case. Further, that trial was carried out at a relatively low burning rate which accentuates the coking qualities of a fuel. The point, however, is of minor importance and does not affect the conclusions drawn from the first phase. A full explanation of our interpretation of "cauliflowering" is given in the original article. It is quite possible that Mr. Darnell may not have come up against this trouble, in which case it may be difficult for him to visualize.

Dimensions of the grid used in the first phase are of minor importance, since, by visual inspection, the fuel bed was uniform and therefore the flow of air was not affected to any appreciable extent.

Before going further, it would be wise to clear up a misunderstanding which has evidently occurred. Mr. Darnell has failed to notice the existence of "ash

plates'' or ''clinker dams'' shown in Fig. 2 (Fig. 6 of the original article). The function of these is to scrape the ashes from the surface of the grate and thus the rear end of the stoker where the links break open is completely screened from the radiation from the furnace. Mr. Darnell has gone to some length to explain that this can equally well be effected by a water back, with which we quite agree. However, the fact that the links, when they open out during their passage over the rear sprocket, are already screened from the combustion chamber rather precludes Mr. Darnell's argument as to the cause of overheating in our case.

In the original article, curves are given showing the actual temperature of the links, every 6 in. during their passage from the feed gate to a point well over the rear sprocket. The temperatures were obtained by fitting a thermocouple in the link, the wires being fed under the top grate surface as it moved forward.

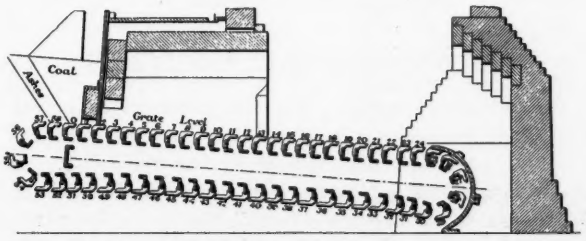


Fig. 2. Setting and stoker showing the arrangement of ash plates or clinker dams

A total of approximately 70 complete tests were recorded. The results show that the links reach a maximum temperature when in contact with the hot fuel bed.

This occurred when the bottom layers of green fuel were fully ignited, which, under the conditions existing in the experiment, was at a point approximately 60 per cent of the length of the fire, i.e., considerably before the place where the links open. Therefore the cause of overheating of the grate surface is radiation from the fuel bed. When the grate surface was relatively bare and exposed to the radiation from the combustion chamber a fall in temperature was recorded. The original paper further shows that, if the grate surface is screened from the radiation from the fuel bed by a layer of relatively inert material, the maximum temperatures attained by the links is considerably reduced.

It can only be hoped that American operators who have to deal with fuels of low ash content and preheated air of relatively high temperatures will read the original article more closely than Mr. Darnell appears to have done and examine the evidence. If they are further interested, a trial, by hand firing the inert material, can easily be made as there is nothing better than proving a statement for oneself.

It is felt that the statement that no trouble will be experienced with air temperatures up to 400-450 deg. F. suggests that Mr. Darnell's experience with wide ranges of fuel is limited. The figure of 350 deg. F., as an economic maximum temperature is, we believe, generally accepted by authorities in both America and Great Britain, although isolated instances are known where air temperatures up to 400 deg. F. give little trouble. The latest source of information on this subject appears in a paper by Robert E. Dillon and Melvin D. Engle on the ''Economics of Preheated Air for Stokers'' given in the Transactions of the American Society of Mechanical Engineers.

For the economics of preheating air above 400 deg. F. Mr. Darnell's attention should be drawn to the development of the regenerative cycle for heating boiler feedwater, which can be obtained in most text books.

In conclusion, may we say that severe deterioration of the grate surface has taken place in our case in spite of proper tempering of the coal, uniform air distribution and adequate protection of the rear end of the stoker from radiant heat and that this has been dealt with adequately by the system of firing relatively inert material on the sandwich system on 21 stokers for the past 12 months.

Hartford, Cheshire, England. J. D. MAUGHAM,
H. B. SPAULDING,
B. M. THORNTON.

Surface Condenser Design and Operation

MR. GUY AND THE WRITER have reviewed the November issue with the article, Surface Condenser Design and Operation, based on our recent paper before the Institute of Mechanical Engineers and we regret that the arrangement of formulæ used tends to make the article misleading particularly in Fig. 1. The block is so arranged that Cases A, B and C have placed beneath them formulæ for the evaluation of the mean temperature difference, t_m. (Figure 1 of the November article is reproduced here without the formulæ in question.)

Case A shows two assumptions of temperature gradient, the vertical lines illustrating the Grashof formula with a pressure drop of 0.4 in. of mercury in which

$$t_m = \frac{(t_4 - t_1) - (t_3 - t_2)}{\log_e \left(\frac{t_4 - t_1}{t_3 - t_2}\right)}$$

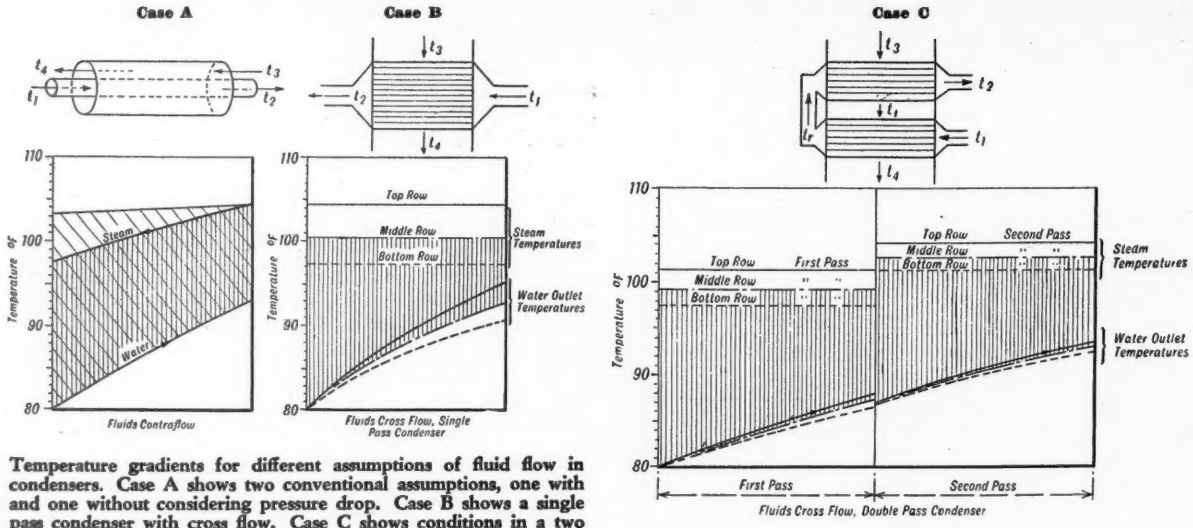
and the cross hatched area of this same Case A illustrating the usual assumption of no pressure drop or t_3 equal to t_4 in which

$$t_m = \frac{t_2 - t_1}{\log_e \left(\frac{t_3 - t_1}{t_3 - t_2}\right)}$$

i. e. both these expressions of t_m are applicable to Case A as drawn.

Case B is what we term the cross flow and the expression for t_m that should appear underneath this is

$$t_m = \frac{t_2 - t_1}{\log_e \left[\frac{1}{1 - \left(\frac{t_2 - t_1}{t_3 - t_4}\right) \log_e \left(\frac{t_3 - t_1}{t_4 - t_1}\right)}\right]}$$



Temperature gradients for different assumptions of fluid flow in condensers. Case A shows two conventional assumptions, one with and one without considering pressure drop. Case B shows a single pass condenser with cross flow. Case C shows conditions in a two pass condenser assuming cross flow

Case C is intended to illustrate the temperature gradient that exists in a two pass condenser on the assumption of cross flow and calculated from the use of the expression as above applied to each pass. Based on equal heat transmitted in each pass the formula becomes

$$t_m = \tfrac{1}{2}\left\{ t_m \text{ First Pass} \right\} + \tfrac{1}{2}\left\{ t_m \text{ Second Pass} \right\}$$

That is the value of t_m for each pass is derived from the formula used in Case B for cross flow, assuming equal water temperature rise in each pass and the intermediate steam temperature as half way between the initial and final temperature.

Another error has crept into the type for Equation 2 on page 515. A multiplication sign has been put in place of a minus sign. This equation should read

$$U_E = QV \div \left[LD \left(1 - \frac{d}{p}\sqrt{n}\right) \right]$$

In the first four equations, reference to t_1, t_2, etc., are given in the small sketches for Cases A, B and C. In the case of the last equation,

Q = Steam flow in pounds per second
V = Specific volume corresponding to the vacuum at condenser inlet
d = O.D. of tube in inches
P = Mean tube pitch in inches
N = Tube plate efficiency

These corrections should be made in the article in question, which otherwise is a useful summary of the section of the original paper dealing with mean temperature differences and rates of heat transmission.

E. V. Winstanley
Condenser Engineer
Metropolitan-Vickers Elec. Export Co. Ltd.
Manchester, England

Reviewing Power Contracts

LONG TERM CONTRACTS for the purchase of power for resale properly include provision for periodic review of conditions and prices during their life. It sometimes works out that arrangements made in times of expansion become much less favorable to one party when loads fall off and local plants need the benefit of operating at better economy than prevailed originally. To postpone review of such agreements when they fall due may appear to be good policy from the point of view of one organization while it puts a considerable burden on the other. It is desirable in the interest of supplying power in a given area at minimum overall costs to work out a fair modification of terms in case either party reaches the point where its costs are adversely affected by continuing the original set-up.

When a large investment has been made, for example, in hydroelectric plant, transmission and substation facilities to supply another system with primary power from one year's end to another at prices agreed upon as equitable when the inter-company agreement was made, such an investment should be protected throughout the life of the contract. On the other hand, if the price of delivered energy becomes burdensome to the purchasing company on account of the idle capacity forced upon its own efficient fuel-burning plants by adverse business conditions, it would seem appropriate promptly to consider the engineering possibilities of price revision when the first operating period ends.

The results of an engineering investigation in cooperation with the system staffs and plant executives may reveal that little can be done by way of readjustment, but this should be determined in any case and not left to ride along in hopes of better times by those who see mainly the investment side of the picture. It does not satisfy the broader public interests of regional power generation and supply to allow matters to drift when the price and cost elements of the case begin

to fall too far apart. A very definite responsibility rests upon the power production and transmission specialist to see that no omission of his own to analyze the situation for the benefit of his clients or employers shall lull those charged with administering the property into a complacent willingness to avoid reviewing unbalanced conditions until they become quasi-critical.

Cambridge, Mass. H. S. KNOWLTON.

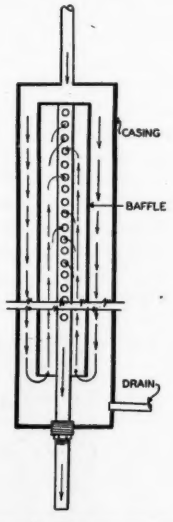
Steam Separator Made of Steel Pipe

WHEN A STEAM separator is needed for use in connection with an engine, or other major detail of a power plant's equipment, it is the part of wisdom to install an apparatus especially designed for the purpose, but where condensation in some minor detail of the equipment gives trouble, the expense of putting in a scientifically designed separator might not warrant its purchase. In that event it might be prudent to rig up one that would answer the purpose.

The sketch shows a separator made of short pieces of pipe. The casing is a 24-in. length of 4-in. pipe; the baffle is a 16-in. length of 2-in. pipe; the perforated pipe is of ¾-in. size.

The top end of the perforated pipe is welded to the top head of the baffle. The bottom head of the casing is then welded in and drilled and tapped to receive a 1½ by ¾-in. bushing. After the ¾-in. pipe has been screwed into the bushing, the top head of the casing is welded in.

The arrows show the course of the steam current, which passes into the ¾-in. pipe through ⅜-in. holes drilled along its wall. The water is whipped out as



Improvised steam separator

the steam makes the upward turn into the 2-in. pipe, and passes through the drain pipe to the trap. This is easily covered with standard pipe covering which improves its efficiency.

I have been using a separator so made in connection with a steam pump for the last 5 yr. and have not had it off the line. It has saved one-half of the oil previously used and the pump never chatters.

Salina, Kan. F. M. MYERS.

Taking Up V-Belt Slack

IT IS OFTEN the case that when some new item finds its way into industrial use, the advantages which it brings into practice are at first only partly realized. Take the V-belt as a case in point. This belt will pull fairly well even when it is rather slack, though there comes a point at which increasing slackness will cause serious loss of transmissive capacity and slipping. It then becomes necessary to tighten the belt.

Now, a V-belt can be tightened by any of the methods used for tightening a flat belt, at least within limits. But a fact that has been overlooked by many is this—it is possible to tighten a V-belt without moving the pulleys farther apart, or without the use of anything in the nature of a wrapper pulley.

It is possible actually to increase the effective diameter of the pulleys on which a V-belt runs, and by that means to tighten it. The V-belt runs in a trough, so to speak, and it is wedge-shaped in section. If the sides of the "trough" or pulley groove in which the belt is running may be moved closer together, the belt will be forced outward into a running position with a greater-radius arc.

In order to do this, the pulley must be made in two parts, and provision made for moving the two parts closer together or farther apart at will. It has been found quite practical to do this, as is evidenced by several variable speed drives employing the principle. The idea is of especial value in mechanisms where it is not possible to move either one of two connected pulleys bodily, and is also a good method to use on V-belt drives between light shafting units. I do not know if V-belt pulleys of this adjustable type have as yet been placed upon the market, but if not, it doubtless is only a matter of time until they will be. The principle is too good to go to waste.

Peoria, Ill. JOHN E. HYLER.

Notes on Rubber Gloves

RUBBER GLOVES give excellent protection from electric shock provided they are sound. With all electrical work, mechanical work is involved. Mechanical work causes wear and possibly puncturing of the rubber so that the gloves are no longer safe for electrical purposes. In order to prevent this wear falling on the rubber, outer protective gloves of leather may be worn, the combination of the two will give both electrical and mechanical protection.

Rubber gloves should be given an electrical test at frequent intervals; any glove found to be defective should have a vee cut in the cuff or the thumbs cut off, so that they will not be used for high voltage work. If facilities for electrical testing are not available the gloves can be blown up with compressed air and cuts and minute punctures can thus be detected.

Herts, England. W. E. WARNER.

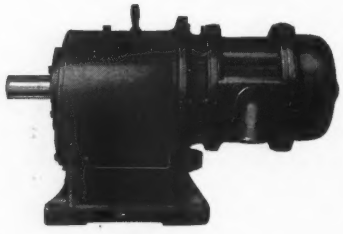
WHEN A NON-SINUSOIDAL wave of voltage of rated frequency and effective value is impressed on a single phase transformer, the effective value of current, the wave form of the current and the core loss will be different from what they would be for a sinusoidal voltage of the same frequency and effective value.

New Equipment

Motorized Reducers Announced by Link-Belt

STILL GREATER COMPACTNESS and economy in self-contained enclosed speed reducing units is obtained by a new line of Motorized Helical-Gear Reducers, announced by Link-Belt Co., Chicago, Ill.

A standard round-frame motor is secured firmly to the side of the reducer housing by means of an adapter casting which supports the motor shaft in over-size, anti-friction bearings close to the pinion, thus assuring good alinement and proper mesh of pinion with its mate. The complete motor, with adapter and motor pinion, may be removed as a unit for inspection or maintenance, without disturbing the alinement of the motor, or of



the gears remaining in the reducer housing; in fact, the motor pinion and gear are removable without disconnecting the driven machine or disturbing the low speed gears.

All gears are of the helical type, with teeth cut from heat-treated alloy steel. Anti-friction bearings are used throughout. The low speed shaft and its bearings are designed to carry overhung loads. A well-braced and ribbed gray iron housing provides a rigid mounting for the bearings, shafts and motor, as well as constituting a liberal-sized reservoir for automatic lubrication of the gears and bearings. Seals are provided at shaft openings to keep the oil in the housing, and the grit and dirt out.

CORINCO CORK TILE in light, medium and dark brown shades and thicknesses 3/8 and 9/16 in., with coved angle and wall base to match, also a nosing for stairways is announced by Cork Insulation Co., Inc., 155 East 44th St., New York City.

Gage Pressure Equalizer

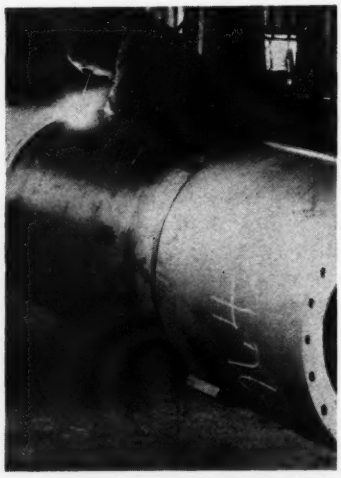
FOR EVENING out pressure pulsations in liquid connections to pressure gages, regulating valves, water level controls, flow meters and other instruments subject to shock, pulsation or chatter, the National Boiler Improvement Co., Washington, D. C., has placed on the market a gage pressure equalizer that is simply put in the line

as part of the pipe connection to the instrument. The damping effect is secured by ironing out the pulsations with a series of spiral grooves in a non-corrosive bronze connector.

Electric Welded Silencer

SILENCERS WHICH the Maxim Silencer Co. build for various Diesel engine plants vary in size from 1 ft. to 30 ft. in length, 6 to 60 in. in diameter and shell from 20 gage to 1/4 in. thickness.

Normal pressure in a silencer is slight but unburned gases occa-

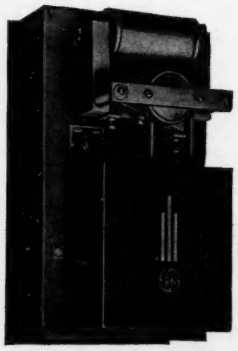


sionally escape through the exhaust system into the silencer where they explode, producing extra pressures, hence requiring strength so that the makers employ welded construction, using the shielded arc process which gives tensile strengths of 65,000 to 85,000 lb. per sq. in., ductility of 20 to 30 per cent elongation in 2 inches. Also they report considerable saving in time and cost of construction over former methods of fabrication.

Most of the welded joints are of butt and lap type, but in the case of the ends of smaller cylinders, edge welds are used. Most of the welding is done in the down position, since the cylindrical shape of the silencers permits rolling them during welding. Two sizes of electrodes, 5/32 and 3/16 in., supplied by The Lincoln Electric Co., Cleveland, Ohio, are used. The accompanying illustration shows a welding operator at work on one of the silencers.

Voltage Regulators of Unusual Design Introduced by G. E.

A COMPLETE LINE OF a-c and d-c generator voltage regulators, radically new and simple in principle, design, and operation, has been made available by the General Electric Company. The new line consists of four types of exciter-field rheostatic regulators, all types being fundamentally the same but with design modifications suited to application and class of service. Types GDA and GFA-4 are for application to a-c machines, and Types GDD and GFD-2 for application to d-c machines. Types GDA and GDD are direct-acting, that is, the rheostatic element is an in-



tegral part of the regulator unit and is actuated directly by the voltage-sensitive regulating device. In all four types, there are no vibrating contacts, the voltage-sensitive

element being a form of torque motor balanced against a spring, and controlled by generator voltage.

At any applied voltage within the range of the regulator, the armature of the torque motor assumes a corresponding deflection against the restoring torque of the spring. This element then remains motionless unless a change in voltage occurs, in which case a proportional change in deflection takes place. In Types GDA and GDD, a dashpot linked to the moving element prevents oscillation and provides dead-beat operation. In Types GFA-4 and GFD-2, a magnetic damping device performs the same function.

Response of the torque motor element is fast and possesses a flat characteristic with respect to load, frequency, and temperature. In all the new regulators, the regulating system remains at rest unless an actual change in generator excitation becomes necessary to maintain voltage.

The two direct-acting regulators, Types GDA and GDD, employ a rheostatic element of an entirely new construction which provides a smooth change in resistance from zero to maximum in a great number of very small steps. This rheostat is small and compact and is operated directly by the torque motor through a simple linkage.

Type GDA direct-acting exciter-field rheostatic regulators are designed for accurate voltage control of small- and medium-sized a-c generators, synchronous condensers, and synchronous motors. They are made in three sizes. Only four leads are required for this regulator—two for the potential circuit and two for the exciter shunt-field circuit. Since the torque motor in the Type GDA is a d-c device, a small copper-oxide rectifier is used to convert the a-c potential of the generator for application to the torque motor.

Type GDD direct-acting exciter-field rheostatic regulators are designed for the accurate control of voltage, speed, or current with small- and medium-sized d-c machines. This regulator is also made in three sizes and requires only four leads for connection to potential and exciter shunt field.

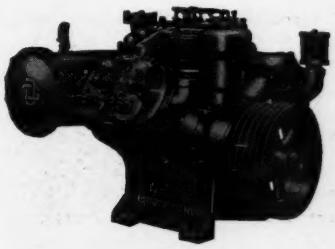
Type GFA-4 exciter-field rheostatic regulators have high-speed features and are suitable for any size or type of synchronous machine. They are considered especially suited to the control of large and important synchronous machines where accurate control and great reliability are essential. Excitation is controlled by automatic adjustment of the exciter field rheostat and by highspeed relays which cut in or out the entire regulating resistance in the exciter field only in case of large changes in voltage. In the Type GFA-4, the voltage-sensitive element is a polyphase torque motor responsive to the average voltage of the polyphase circuit to which it is connected. Rotating cam contacts provide positive mechanical anti-hunting which is independent of exciter voltage or the electrical characteristics of the machine or system under control. The complete standard Type GFA-4 regulating equipment consists of the regulator proper, a motor-operated exciter-field rheostat, with field-reducing resistor, a relay panel with a normally open and a normally closed high-speed relay, an adjusting rheostat, and a transfer switch. Like the other regulators in the new line, Type GFA-4 operates only when a change in voltage occurs.

The Type GFD-2 exciter-field rheostatic regulator is intended for voltage, speed, or current control of large d-c machines. This regulator is essentially the same as the Type GFA-4, except for the torque motor which is in this case a d-c device, and operates in the same manner. It may be obtained with or without the high-speed features.

New Gardner-Denver Compressor

GARDNER-DENVER Co., Quincy, Ill., has developed a new 6-cylinder two stage water cooled compressor embodying distinctive features which provide more delivered are, with a resultant saving in power cost.

An outstanding feature of design is the use of four small-diam-



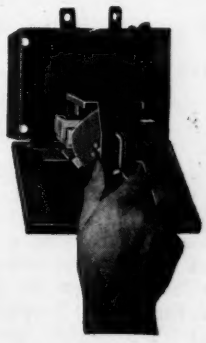
eter low pressure cylinders, instead of two large ones, this construction permitting the use of small, lightweight pistons and considerably reducing the inertia loads. The use of two pairs of low pressure water cooled cylinders provides lower air temperatures than previously obtained in small vertical compressors, with corresponding saving in horsepower. By watercooling the cylinder walls, lower wall temperatures are obtained, with better lubrication and longer life. Distortion of cylinder walls from heat is eliminated, and, in addition, the compressor operates independently of atmospheric temperatures.

These 6-cylinder compressors, it is stated, adequately meet the need for more compact machines having efficiencies comparable to those of large two-stage horizontal compressors of the same capacity.

Mountings include motor mounted on shaft; V-belt to electric motor, diesel or gasoline engines; or direct connected through flexible flywheel coupling to motor and engines.

New Swing-Out Interior Switch

THE ENGINEERING department of the Switch & Panel Division, Square D Company, Detroit, has announced the introduction of a new line of Type D 30-amp. switches with a novel swing-out interior which is said to greatly cut the time and cost of wiring. The main feature is the fact that the base and operating mechanism is mounted on a metal supporting plate which is hinged to the side of the box. By pulling on the operating handle, the entire interior swings out and away from the



box, leaving the entire box area open for unobstructed wiring and conduit connections. With the wire and conduit in place it is merely necessary to swing the interior back into place and the connections can be made. The hinged interior is self aligning. The handle slipping into the slot at the side of the switch automatically brings the interior into place and retains it there. The interior may then be

secured by a single set screw. The compact size of the interior gives plenty of room for grounding bushings in all knockouts. The hinged support is elevated from the back of the box to provide ample space for laying wires behind the base without pinching the wires.

New Electrode For Hard-facing and Cutting Edges

A NEW ARC welding electrode which is designed for restoring worn cutting edges on tools of all kinds and which is said to permit savings of 20 to 25 per cent in tool cost is announced by The Lincoln Electric Co., Cleveland, Ohio.

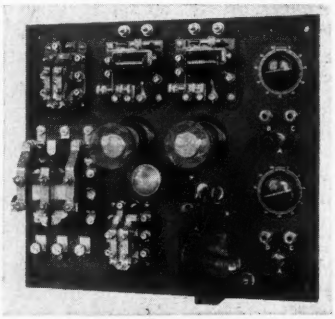
By using this electrode, lathe tools, bits, milling cutters, drills, cutting and forming dies and all other tools which have become worn in service can be given a new and harder cutting edge than has heretofore been possible. Tools can be refaced an unlimited number of times with this electrode. Also new tools using ordinary steel in place of high speed steels can be provided with a cutting edge.

Automatic Repeat Process Timer

FOR USE IN connection with a wide variety of electrically-operated devices and machines requiring automatic timing of the "Power-on" "Power-off" periods. The Electric Controller & Mfg. Co., Cleveland, Ohio, announce the development of an Automatic Repeat Process Timer.

This timer is built in four standard sizes and is designed for operation on 110, 220, 440 or 550 volt circuits of any standard frequency. Operating on the principle of the time required to charge a condenser, it provides a quick, convenient means for closing an electrical circuit for a definite length of time, and then opening the circuit for a similar, or different time, as desired, and repeating this cycle of operation as long as the control push button or master is closed. Both the "Power-on" and the "Power-off" periods are independently adjustable to give time desired.

The "Power-on" period can be adjusted from .05 seconds minimum to .90 seconds maximum on the smallest size of timer. The "Power-off" period of this same size timer is adjustable over a similar range of time. With both the "Power-on" and "Power-off" periods set at minimum time, the timer will provide 550 operations per min. With the largest size of timer, the "On" and "Off" periods are adjustable between a range of .12 seconds minimum and 7.5

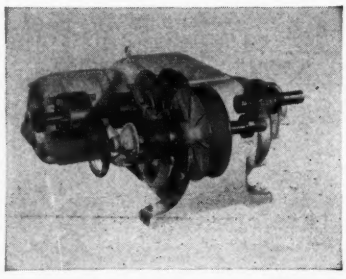


seconds maximum. Timers, of course, could be supplied with a different range of time for the "On" period than is supplied for the "Off" period.

The accompanying illustration shows this timer with its two independent adjusting dials for each circuit. The timer as shown has been removed from its enclosing cabinet in which is also mounted small condensers for both the "On" period and the "Off" period. Complete timers are shipped with these condensers properly wired to the correct terminals.

New "Varidrive" Motor

AN IMPROVED development in variable speed for use in many industries is announced by the U. S. Electrical Manufacturing Company, of Los Angeles and Chicago. The accompanying phantom view of the U. S. Varidrive Motor has been made in order to



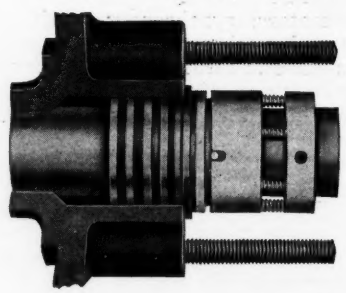
show a new lever arm construction developed for the larger horsepower ratings, and to show how the formerly separate units consisting of a constant speed motor, a variable speed device, and a gear case have been built into one compact unit at a great saving in space, in addition to the economy effected due to the elimination of mounting bases and transmissions, such as couplings, fans, and belts between the component parts.

The phantom view also shows how the speed change is obtained by the micro-speed control which varies the effective driving diameter of the Varidiscs. These discs expand and contract for higher and lower speeds transmitting power through the Varibelt to the take-off shaft. This new motor being self-contained can be conveniently direct connected to machinery. It places at the operator's command any variation of speed, so that the driven machine can be operated at its highest capacity at the will of the operator.

Shaft Packing for Centrifugal Pumps

A NEW TYPE of mechanical seal called Dura Seal has been brought out by the Durametallic Corp., Kalamazoo, Mich. This was developed to seal more effectively power equipment such as pumps and exhausters, working gritty or corrosive liquids and gases and can be applied to ordinary stuffing boxes.

On moderate pressures the out-



side assembly, shown here, is recommended. In this a bushing is placed in the stuffing box in which it remains stationary. In the grooves with which this bushing is supplied, flexible metallic or other suitable packing is applied to prevent leakage along the stuffing box wall.

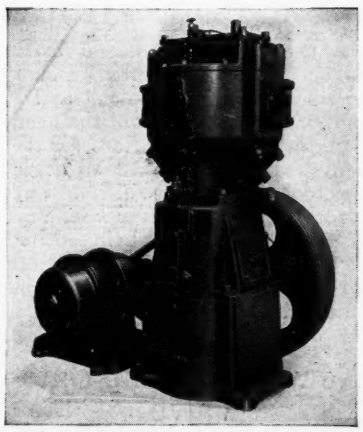
Outside the stuffing box the packing proper or rotating member is located. This consists of a collar which is set on the shaft, ahead of which toward the stuffing box is a compression chamber in which flexible packing is provided to prevent leakage along the shaft,

and finally there is a seal ring which rotates against the bushing. The face of the bushing and the face of the seal ring of the rotating member are ground or lapped in, making a perfect joint. There is no wear on the soft packing in the compression chamber because it rotates with the shaft.

A wide variety of metals and other materials may be used in the construction of Dura Seal so that it can be made to resist corrosion by practically all chemicals, and grit cannot get between the seal ring and the face of the bushing or gland.

New High Vacuum Pump

TO MEET THE NEEDS of canners, packers, fumigators and other process industries, the Worthington Pump & Machinery Corp., Harrison, N. J., announces a simple,



self-contained high vacuum pump. The machine is a double-acting single pump of vertical design and can be furnished in either one or two stages. All running parts operate in an air-tight and dust-proof case; adjustments are provided for wear as in large size more expensive equipment and lubrication of all bearings is force-feed.

Brown Portable Potentiometer

BROWN INSTRUMENT COMPANY announces a new Portable Potentiometer designed to enable pyrometer users to check their Potentiometers, Millivoltmeters and Thermocouples quickly and accurately.

The combination of a step-switch and slide wire makes it possible to read the indicating scale to .01 millivolts over a total range of 71 millivolts. This step-switch and slide wire combination is equivalent to having a slide wire 109 in. long. The indicating scale is 17 in. long, making the smallest scale division (.05 mv.) over 1/16 in. in width.

A fully enclosed, suspension type galvanometer is used. Having a very short period (approximately 2 sec.) readings can be taken rap-

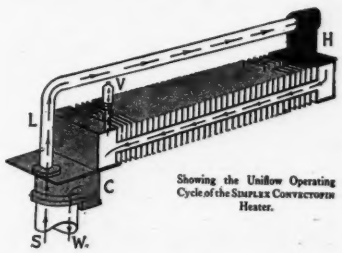
idly, as the galvanometer responds immediately when dial is moved to a new position. Two sets of binding posts and a toggle switch, provided for thermocouple checking, further facilitate taking check readings quickly and accurately.

The potentiometer circuit has been designed primarily for checking pyrometers and thermocouples. In addition, this new portable potentiometer can be used as a measured source of E.M.F. in checking recording potentiometers of the self-balancing type. The circuit draws only three milliamperes from the dry cell, giving the dry cell a life of several months and permitting the instrument to be used for several hours on one standardization of the battery current.

In addition to being simple in construction and extremely accurate, this new Brown Portable Potentiometer is small in size and light in weight. It is 9⅜ in. wide by 10¼ in. deep by 6¾ in. high, and weighs only 12¾ lb.

Single Pipe Built-in Heater

A CHANGE in design of built-in heaters, shown schematically, is announced by the Commodore Heaters Corp., 11 West 42nd St., New York City. The heater operates on the uniflow principle, with series-parallel circulation and easy venting. Steam comes in at S,

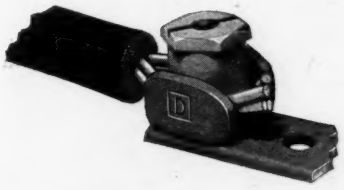


Showing the Uniflow Operating Cycle of the SIMPLEX CONVECTOPIN Heater.

travels up the loop L, over to the heater H, and enters the heater proper. Air and water, if any, are pushed ahead, all flowing in the one path but in the same direction. The air is eliminated by an air valve V, while the water of condensation passes on through the compensator C, and flows from the heater at W, out of the single pipe connection.

New Solderless Connector

THE SWITCH & PANEL Division, Square D Company, Detroit, Mich., has just announced in their January issue of the Square D Digest, a solderless connector of new design. The connector consists of a copper



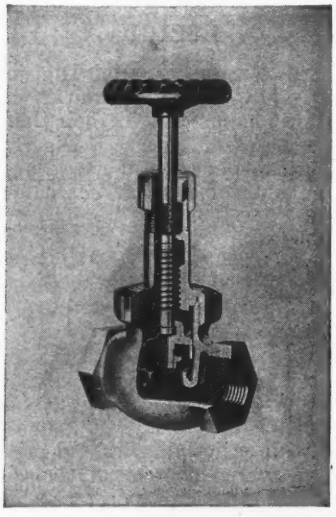
cup with enclosing sides and raised lip of curved contour at the wire entrance, a specially designed hexagon nut and a stud. The hexagon nut, which can be turned by either a screwdriver or a wrench, presents smooth rounded surface to the conductor and forces the wire strands into the recess of the cup and compresses them so forcefully according to Square D engineers, that a much better contact and more secure mechanical bond is formed than by the ordinary solder lug.

The design of the connector precludes any possibility of vibra-

tion loosening the conductor, insuring a positive permanent connection. The connector can be used for either solid or stranded conductors. One outstanding feature of the new connector is the fact that it fits in the same space as a solder lug, so that it can be adapted to standard switches without the danger of exceeding electrical clearances. The new solderless connector is made in two sizes: for No. 14 to No. 4 wire inclusive (nominal 60-amp. size) and for No. 14 to No. 1 wire (100 amp. size). The Square D solderless connectors are optional on Square D range combinations as well as being available in standard packages for existing installations.

New Globe and Angle Valves

THE FAIRBANKS CO., New York City, has placed on the market a new line of renewable bronze, angle and globe valves. Some of the features the manufacturers claim for these valves are: The radial seat, between body and bonnet, insures a tight joint and perfect alinement of all parts; the seat is drawn to a tight joint by the union nut without sliding or scraping the surface of the seat. The disc ring is com-



posed of long-fiber asbestos compounded with vulcanizing elements and is given a special cure.

The disc holder is of standard dimensions, permitting the use of other standard makes of disc rings. The protected top seat above the threads on the stem gives assurance of a clean tight joint when the valve is fully opened for the purpose of repacking the valve under pressure.

New Pyrometer Lance

THIS instrument, of low resistance type, has the protecting case and handle in a single aluminum, streamlined casting. It is a portable hand instrument to serve for checking temperatures in all applications where a wall type pyrometer is used and is available for three temperature ranges, to 800 deg., to 1600 deg. and to 2500 deg. F. Some uses are to gather heat data in chemical and industrial processes, as a trouble shooter to detect boiler room losses due to defective baffles, loose bricks, excess air, soot, scale, or leaky set-

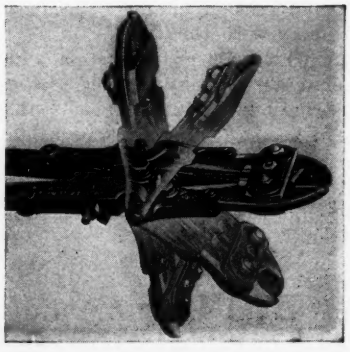
tings, standards for comparison at key points and a definite load being made when the boiler is clean and all baffles and setting in perfect condition. Later readings, checked against these standards will detect losses with attendant fuel waste. This Hold Heet pyrometer has been designed for low cost, accuracy, rugged construction and with heavy thermocouples, the dial being 2½ in. diameter and scale 2½ in. long, graduated in degrees F. It is manufactured by Russell Electric Co., 340 W. Huron St., Chicago, Ill.

Novel Hydraulic Turbine

AMONG THE MOST important material at present in course of construction at the works of Escher Wyss & Co., at Zurich are four impulse turbines for the Etzel (Switzerland) hydroelectric power station. The units are of the vertical type and are designed to develop 22,000 hp. each under a head of 1575 ft. Of particular interest is the arrangement of the water inlet piping; two parallel pipes on both ends of the power building. One nozzle of each turbine receives the water from one and the same pipe, whereas the second nozzles are connected to the other. By this arrangement it is possible to operate all turbines under half load, should one of the pipe lines have to be repaired.

Porter Swivel Head Cutter

BY THE USE of an ingenious but simple device the standard bolt clipper has been made into a tool practically universal in its applica-



tion by H. K. Porter, Inc., Everett, Mass. The HKP swivel head cutter works equally well in all positions because the cutting head swivels to any angle on either side of the handles, from nothing to a right angle.

A special section joined by a ball and socket joint, with a shoe for holding the cutter head and a positioning spring to hold the head in the desired position, are all the changes made in the standard rigid type tool. The shoe will hold any standard head of a given size, clipper cut, center cut, chain cutter, nut splitter, etc., and the change from one head to another can be made quickly and on the job.

New Design Clip Gate Valve

READING-PRATT & CADY CO., Inc., Bridgeport, Conn., has added a clip type gate valve with new design features to its line of valves. This valve has a round bonnet which construction permits the use of a

male and female joint with asbestos gasket assuring tightness.

A full U-bolt is used to hold the bonnet joint tight. When the nuts on these bolts are tightened, pressure is equalized on both sides. Three sets of guides on the body and two solid eye lugs on the bonnet hold the U-bolt and eliminate possibility of slipping.

Among the internal features are the full thickness I-beam cast wedge which brings sturdiness to the valve seat and permits the use of full size body guides to assure correct seating. A horseshoe connection is used to assemble the spindle and wedge. This provides greater strength and greater lifting surface than the usual tee slot connection. Guide slots in the wedge are machined.

Multiple Recording Colors

READING OF MULTIPLE-POINT instrument records is simplified by a new system of "numerals in colors" introduced by Leeds & Northrup Co., Philadelphia, Pa. This marking system can be specified on Micromax strip-chart recorders for 2, 3, 4 or 6 points. With each of the thermocouples, resistance thermometer bulbs or other primary elements identified on the chart by a numeral, and each numeral distinguished from the others by being printed in a contrasting color, reading of records is made easy, errors are avoided and time is saved. Colors used for printing the numerals are: black, green, red, violet, yellow and blue. The print-wheel on these recorders has a separate inking pad for each point to be recorded.

Rubber Lined Metal Tanks

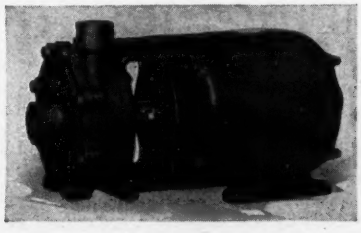
ANNOUNCEMENT of a new rubber lining for metal tanks to protect them in use against the action of acids and corrosive liquids, is made by The Goodyear Tire & Rubber Co., Akron, O. Important in the new development, which has been in production for about a year, is the fact that the adhesive with which Plioweld is applied to tanks, is a rubber derivative, applied to the clean metal which actually welds the resilient rubber to the metal during the process of vulcanization. The adhesive itself is a corrosion resistant material affording added protection in the application.

Goodyear adhesive which is used in the application of the rubber lining to the tanks offers another new development feature worthy of note, in that it is dissolved in a non-toxic solvent so that hazards to workmen making the application are avoided. The usual thickness of this new lining is $\frac{1}{16}$ in., and the product is applicable to all shapes and sizes of tanks made of wood, steel, aluminum and lead.

Plioweld, the new lining, is said to offer these advantages: effectively sealing in most corrosive liquids, hot or cold, preventing tank leaks, corrosion and waste; will not oxidize nor slough off; it will not crack nor buckle under alternate drying and wetting.

Worthington Centrifugal Pump

DEVELOPMENT of its two-stage Monobloc centrifugal pump is announced by the Worthington Pump & Mach. Corp., Harrison, N. J. The low power requirements and simplicity of this modern unit make it especially applicable to all services requiring small capacity and medium discharge head. The casing, designed to withstand 150 lbs. pressure, is bolted directly to



the motor frame without an intermediate distance piece, thus eliminating the necessity for a baseplate.

The unit can be mounted vertically or horizontally, has steep head-capacity characteristic and is ideal for: air conditioning installations, refrigeration service, boiler return and chemical process work.

Foxboro Universal Meter

A UNIVERSAL METER designed to measure any fluid under any industrial condition is the latest addition to the complete line of meters manufactured and sold by The Foxboro Co. of Foxboro, Mass. Simple recording, or pressure compensation or correlated temperature, pressure, and flow records, are obtainable in a universal meter without special design.

This new measuring instrument has a flow rangeability of ten to one. The charts have uniform graduations and where it is necessary or desirable, temperature and pressure records may be recorded on the same chart with the flow. When a multiple-pen recorder is furnished, all pens move about the same center of rotation and will not interfere with each other at any point in their travel.

A new mechanical integrator has been built especially for this meter. This integrator shows the total flow on an easily read counter. No multipliers are necessary since the counter reads directly in terms of total flow. A recording pen can be added which makes a mark on the chart rim when the integrator adds a given amount to its count.

In addition to the Recording and Integrating features the Universal Meter can be furnished with a transparent indicating scale that makes it possible for the flow to be read at a glance. The Universal Meter is for measuring steam, oil, air, water, gas, acids or any other fluid under any industrial condition.

JOHN BERGEN, chief engineer of the Alexander Bauer Estate reports interesting results from installation of a Link-Belt automatic underfeed stoker, which is available in sizes for 10 to 250 boiler horsepower, in a loft building under his charge. According to his records, fuel bill for Pocahontas coal, hand-fired during the season 1932-33 was $1350. After installation of the stoker Franklin County screenings cost $930 for 1933-34, a saving of $420 or 31 per cent. Besides a less expensive grade of fuel and smaller tonnage, more even heating and better smoke prevention were reported as results of the installation.

News From the Field

PURDUE UNIVERSITY will offer a new curriculum in "Public Service Engineering" beginning next September, according to a recent announcement. This Public Service Engineering curriculum has as one of its major objectives the preparation of engineers capable to deal with the technologic problems of government. Basic instruction will be given in the elements of civil, electrical and mechanical engineering, while the requirements in science, mathematics, languages and mechanics will be the same as for the standard professional engineering curricula. Considerable attention is also to be devoted to government and social science, in order to aid the student in gaining an appreciation of the relation of engineering to the public and to its agent—the government.

NORTHERN EQUIPMENT CO., Erie, Pa., announces the appointment of W. J. McDonough, as Sales Manager. Mr. McDonough has been associated with the Copes organization since 1922. Thomas A. Read has rejoined the engineering department of Northern Equipment Co., with which he was associated from 1928 to 1933. His return will permit further expansion of the research and development program now under way at the Erie plant.

ARTHUR D. DURGIN, who has been handling boilers the last 15 yr. for the International Engineering Works, is now in the Boston office of The Bigelow Co., Kendall Sq. Bldg., Cambridge, Mass.

AMERICAN ENGINEERING CO., Philadelphia, Pa., announces that the sale of all Taylor stoker equipment for the southern territory will be handled by the Boiler Equipment Service Co., 686 Greenwood Ave., N. E., Atlanta, Ga. E. A. Brooks, President of the Boiler Equipment Service Co. has added this new stoker division to the company after years of experience with power plant equipment and installations in the South. R. N. Ruiter, a stoker specialist, will be in charge of the new stoker division.

DR. LILLIAN MOLLER GILBRETH, of Montclair, N. J., Consulting Engineer in Management, has been appointed Professor of Management at Purdue University, effective next September, it was announced recently. Dr. Gilbreth has served in addition to the industries and government of this country, many of the leading organizations of Europe. She was born and educated in California and holds degrees from California, Brown, Michigan, Rutgers and Russell State College.

ERNST WATER COLUMN & GAGE CO., Newark, N. J., has moved its Austin, Tex., office to Wichita Falls, Tex., in charge of Theo Langenbergh; other representatives recently appointed are as follows, Kansas City, Mo., H. C. Freese, 3521 Baltimore Ave.; Indianapolis, Ind., H. L. Kister, 736 Carrollton Ave.

ELGIN SOFTENER CORP., Elgin, Illinois, has taken over the Isometer which has a variable orifice principle of operation for the measurement of steam, water, oil, and other liquids and gases. The Isometer Corp. of Milwaukee will now be operated as a division of the Elgin Softener Corporation, with executive offices and manufacturing facilities at Elgin, Ill.

TEST RESULTS of a Sulzer, 5500 hp., 2 cycle, single acting Diesel engine built for the New Zealand Steamship Co., are reported, by Consul M. W. Altaffer through the Machinery Division of the Bureau of Foreign and Domestic Commerce, to set a new record. The official test showed a consumption of 0.33 lb. of oil per brake horsepower at full load and 0.328 lb. at three-quarters load. Two of these engines have just been completed for the above company and it is reported that 10 more are in the process of manufacture for other customers.

ANNOUNCEMENT has been made of the Great Lakes Power Show and Mechanical Exposition to be held on the steamship Seeandbee, June 24 to 28, which will be docked one day each at Buffalo, Cleveland and Detroit. The men on the advisory board represent nearly every engineering organization whose members might be interested in the power show and in addition representation is had by the automobile industry, central power stations, consulting, educational and marine fields. Headquarters are at 3910 Carnegie Ave., Cleveland, O., with Ernest H. Smith as manager.

For the Engineer's Library

DIESEL ENGINE DESIGN. By Harold F. Shepherd. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York City. Size 6 by 9 in., cloth bound, 218 pages. Price $3.50.

As its title indicates, this is a book on Diesel engine design but it is written so practically, so clearly illustrated and simply explained that it may be of much more value and interest to the engineer than are many of the usual Diesel engine books ostensibly written for the operator. Calculation methods given are those which the author has found from practical experience were most easily applied and remembered. Derivations of formulas are not given, a fact which greatly increases the readability of the text.

HANDBOOK OF CHEMISTRY AND PHYSICS, Nineteenth Edition. Editor in Chief, Chas. D. Hodgman, 1934 pages, 6¾ by 4½ in. Flexible Fabricoid, Gilt edged. Published by Chemical Rubber Publishing Co., Cleveland, Ohio, 1934. Price $6.00.

This remarkable handbook contains an astonishing quantity of technical information. It represents an amazing amount of physical and mental effort on the parts of thousands of technicians and scientists over innumerable years. Considering its own history alone, it is a 21 yr. accumulation of necessary and valuable data for the scientist and engineer; information highly essential in the commercial, educational and research laboratory. In its previous editions it has always been unusually complete and up-to-date, but this year it is more comprehensive than ever. Also it has been improved by dividing the material into five sections, each indicated by inserts of stiff colored paper on which is printed a summary of the contents of that particular section. The five sections into which the Handbook is divided are: 1, Mathematical Tables; 2, Properties and Physical Constants; 3, General Chemical Table; 4, Heat and Hygrometry, Sound, Electricity and Light; 5, Quantities and Units—Miscellaneous Tables.

ELECTRON TUBES IN INDUSTRY, By Keith Henney. First Edition. 490 pages, illustrated, cloth, size 6 by 9 in. Published by McGraw-Hill Book Co., Inc., New York, 1934. Price $5.00.

To those engaged in the radio industry, the electron tube is a familiar and well understood device. In the hands of the radio engineer, the thermionic tube or "valve" as they call it in England, has developed from a simple two or three element device to a complex affair having as many as six elements and so many terminals that the tube base manufacturer has difficulty in finding room for them. And at the same time it has grown from a delicate glass and metal device of fractional watt capacity to (in some instances) heavy, steel enclosed cylinders, weighing a hundred pounds and capable of carrying a hundred kilowatts or more. Also, in this same period its functions have been extended from one of simple rectification to generation and amplification, voltage, current and frequency control, volume control, noise suppression, and many other purposes.

Naturally, a device, so flexible and so versatile has found many applications outside of the field in which it was first developed. Its first use in general industrial service probably was as a rectifier for small alternating currents—for battery charging—but it soon found other uses. Its amplifying properties almost immediately suggested a score of uses, and with the application of the light sensitive tube or photocell, its use became indispensable. As a generator of high frequency current it found use in industrial heating processes. As an instrument of precision it was incorporated into instruments and devices for the measurement and control of industrial processes of many kinds, and the thermionic principle gave new life to the Braun tube and so made possible that marvelous instrument, the modern cathode-ray oscillograph. In the measurement of light and color and in sorting and grading processes the photocell has been put to a great many uses, and of course wherever the photocell is used the amplifying tube is its inevitable companion.

Because of this extension of the use of the electron tube into industry, a book on the subject is welcome. Mr. Henney has written an interesting book in which he presents the practical aspects of electronics—what the electron tube is doing toward making processes simpler, cheaper, safer, or in making possible new methods of control of manufacture. The material is presented simply and clearly without the use of mathematics and should be of considerable interest and value to the industrial engineer as well as to the teacher and student. While it is difficult to cover all the applications of a device so universally useful as the electron tube in a single book, the author has done very well and the material he presents is up-to-date and quite comprehensive.

THE V. D. ANDERSON CO., 1935 West 96th St., Cleveland, O., has issued a pamphlet describing a new inverted bucket type steam trap which has been given the trade name Super Silvertop. The pamphlet contains not only illustrations to aid the description of the trap but a table of complete specifications and list prices.

GENERAL ELECTRIC Co. has recently issued two bulletins, one on G. E. Arc Welders, designated GEA 1440C and the other Welding Electrodes and Accessories, GEA-1546B.

INDUSTRIAL CABLE is the title of Bulletin GEA 1838 just published by the General Electric Co. In this publication are described and listed all the standard types of insulated wire and cable that are used by industrials for transmission, distribution and control, as well as for use on or with electric equipment such as mining machinery, locomotives, arc welders and Neon signs.

SIMPLEX WIRE & CABLE Company announces Anhydrex, a recently developed, non-water absorptive, rubber insulation for wires and cables that are subjected in service to partial or complete submersion in water. Contrary to popular opinion rubber does absorb water and ordinary rubber insulation is not waterproof. Anhydrex is the culmination of a lengthy research program which has shown why rubber absorbs water and how absorption can be prevented.

The complete story of the development of Anhydrex rubber insulation has recently been published by the Simplex Wire & Cable Company and may be obtained upon request.

BINKS MANUFACTURING CO., Chicago, Ill., offer an 8-page bulletin on indoor forced draft spray cooling towers presenting complete information about constructional features, picturing a number of installations, showing typical arrangements, and giving size and capacity data and specifications. Also a similar 8-page bulletin devoted to atmospheric spray cooling towers for air conditioning and refrigeration, with complete engineering information and other helpful data.

COMPLETE DETAILS of a newly designed line of compressors known as Type T are given in Bulletin 728 recently published by the Chicago Pneumatic Tool Co.

MERCO NORDSTROM VALVE CO., Pittsburgh, Pa., subsidiary of the Pittsburgh Equitable Meter Company, Pittsburgh, Pa., has recently issued a 32-page bulletin describing "Merco" lubricants for Nordstrom Lubricated Plug Valves. This bulletin gives detailed information on the correct type of "Merco" lubricants to be used in over three hundred different services.

INDEX to the A.S.T.M. Standards and Tentative Standards as of January 1, 1935, has just been published and may be obtained, without charge, by those interested, from the Society headquarters at 260 South Broad St., Philadelphia, Pa. The standards covered number some 730 and the index is a decided advantage to purchasing agents, engineers, architects and others.

REPUBLIC STEEL CORP., Massillon, O., has issued a new edition of the subject booklet containing latest authentic data on the various members of the Enduro 18-8 family of stainless steels. An important feature of this 16-page, illustrated booklet is a table showing the degree of corrosion-resistance exerted by Enduro stainless steel, Types 18-8, S and AA in the presence of several hundred individual chemicals, solutions and other reagents.

SCHUTTE & KOERTING CO., Philadelphia, Pa., is distributing a new bulletin designated as 18-R describing Rotameters, the trade name for a particular type of flow meter applicable to the measurement of flow of water, chemicals, food products, solvents, alcohols, gases, acids and oils. The bulletin shows several new developments such as automatic load proportioners, automatic flow controller, new types of flow alarms and several new designs of direct indicating rotameters.

BETHLEHEM STEEL CO., Bethlehem, Pa., has just issued a bulletin entitled Bethlehem Light Sections, dealing with beams, columns, joists and stanchions. These light sections supplement the series of wide flange structural shapes and extend their application and consequent economies to types of buildings where heavier shapes cannot always be used advantageously throughout. The bulletin is well illustrated with photographs of buildings using these light sections and contains tables of properties and weights.

CARBONDALE MACHINE CORP., Carbondale, Pa., has just issued its bulletin W-207-E17, entitled "Capacity and Design Standards for Steam Jet Refrigeration," written by C. F. Hendrie, manager of Air Conditioning Division, Carbondale Machine Corp. The bulletin is an informative treatise on the subject, going into general design and arrangement of equipment, materials of construction, methods of control, capacity and economy, and is sufficiently illustrated with halftones, line drawings and curves to aid in an understanding of this system of refrigeration.

DETAILS AND ADVANTAGES of the Multi-V-Drive with Goodyear emerald cord V-belts are enumerated in bulletin L-400-B5 of the Worthington Pump & Machinery Corp., Harrison, N. J. These drives are available for power requirements from fractional to 1500 hp. in 25,000 stock combinations and for unlimitted special applications.

AMERICAN METER CO., 60 E. 42nd St., New York City, has released a new catalog and instruction bulletin on the Metric Indicating Flowmeter. This bulletin, Number E-3, is attractively printed and fully illustrated with diagrams for various types of installation. It is published in the new 8½ by 11 in. size for looseleaf binder. Other bulletins of the series are AG-1, Meter Proving and Testing Apparatus; Cubic Foot Standards; AG-3, Wet and Dry Test Meters; Demonstration Meters; AG-4, Demand Meters—Recording, Indicating; AG-6, Service Cleaners; E-15, Metric Wide Range Orifice; Needle Valves and Fittings; E-21 Recording Gravitometer; EG-40, Ironcase Meters; E-5, Rate-Volume and Liquid Level Controllers; and E-12, Base Pressure and Base Volume Indexes.

SOMEWHAT enlarged but still very compact and manageable, the 1935 catalog of the Chaplin-Fulton Manufacturing Co., Pittsburgh, Pa., just issued, is especially useful to those responsible for the safe and economical distribution and regulation of natural and manufactured gas in private dwellings, mills, factories, and street mains, and for the controlling of the steam pressure and gas fuel supply to steam boilers. The catalog is well printed, illustrated, and provided with charts and tables. The types of regulators described and shown cover all the more common forms of service for both natural and manufactured gas, and the availability of special regulators for many special purposes in the use of steam, water, oil and air is made plain.

INGERSOLL-RAND CO., New York City, is distributing its bulletin No. 9212 illustrating the various types of aftercoolers made by the company and explaining the reasons why aftercoolers are needed and how the different types of aftercoolers fit into certain compressor plant conditions.

LINK-BELT CO., Chicago, Illinois, has recently issued a bulletin designated as Book No. 1374, illustrating and describing Link-Belt V.R.D. variable roller drive which is a self-adjusting variable speed gear at present built for fractional horsepower duty.

HOLD-HEET pyrometers of wall and lance types are described and illustrated in a circular from Russell Electric Co., 350 W. Huron St., Chicago, Ill., which gives applications, sizes and prices.

NORTHERN EQUIPMENT CO., Erie, Pa., has published, as folder No. 137, an illustrated paper by E. G. Grady, Plant Engineer, on "Operating Experience at Masonite with High-Pressure Boiler Feed Control."

SMOOTH-ON MFG. CO., Jersey City, N. J., has just issued a revised edition of its helpful instruction book entitled, Home and Auto Repairs.

YARNALL-WARING CO., Philadelphia, Pa., has just published its bulletin WG-1804 giving information on the Yarway Eye-Line Indicator which is particularly useful for high boilers as it brings the water level reading down to the most convenient position for the boiler operator.

NORTON CO. of Worcester, Mass., is distributing a bulletin entitled Grinding Wheel Information and Selection which contains a great amount of technical data of value to engineers confronted with grinding problems.

TRANSFORMERS FOR INSTRUMENT and metering service is the title of a new catalog, No. 152 issued by the Allis-Chalmers Mfg. Co., Milwaukee, Wis. This is a valuable and attractive 36-page booklet, more than a catalog in fact for it presents a clear technical discussion of the whole subject of instrument transformers and data concerning their use. List prices of the equipment listed is given together with dimensional data and curves showing performance characteristics.

LOUIS ALLIS CO., Milwaukee, has recently issued a Price Wheel, a circular sliding chart by means of which the price of any of their A.C. polyphase motors can be instantly determined. It is attractively designed in red and black, is of heavy cardboard 8 in. in diameter and is made for hanging on the wall. In using the chart it is merely necessary to point the arrow to the desired horsepower and the speed rating, and the frame size and list price of seven different types of motors will appear in the respective "windows" provided in the face of the chart. It is for motors of 220, 440 or 550 v., 2 or 3 phase, 60 cycles.

Power Plant Construction News

Calif., Burbank — Knowles, Sherrod & Knowles Pottery Co., recently formed, plans installation of electric power equipment in connection with extensions and improvements in former local pottery of Empire China Co., West San Fernando Road, Burbank, which has been acquired for new chinaware plant. Entire project will cost in excess of $60,000. Harold H. Knowles heads new company.

Calif., Los Angeles—Purex Corporation, 1001 East Sixty-second Street, manufacturer of washing compounds, etc., plans installation of electric power equipment in new multi-unit plant in South Gate industrial district. Entire project estimated to cost close to $100,000.

Calif., San Gabriel — Golden West Brewing Co., Seventh and Kirkham Streets, Oakland, Calif., plans installation of power equipment in proposed new brewing plant at San Gabriel, where site has been purchased. A boiler house will be built. Entire project is reported to cost close to $125,000.

Ga., Atlanta—Georgia Power Co., is arranging a fund of $2,135,000 for new construction, extensions and improvements during 1935, including additions in transmission and distributing system, power substations and miscellaneous work.

Ill., Belleville — Safety First Coal Co., plans installation of power equipment in connection with proposed rebuilding of portion of coal-mining properties, near Belleville, recently destroyed by fire. Loss about $50,000.

Ill., Chicago — Electro-Motive Corporation, affiliated with Winton Engine Corporation, 2160 West 106th Street, Cleveland, Ohio, both subsidiaries of General Motors Corporation, Detroit, Mich., plans installation of electric power equipment in new plant on site near Chicago, now being secured, for production of Diesel locomotives and parts. Plant will comprise several units, reported to cost over $500,000. It is expected to be ready for service late in the summer.

Ill., Chicago — Kraft-Phenix Cheese Co., 400 Rush Street, Chicago, plans installation of electric power equipment in new additions to plants at Freeport, Ill., Atlanta, Ga., Plymouth, Wis., and Montreal, Que., including improvements in present units. Entire project will cost over $750,000. Company engineering department will be in charge.

Kan., Washington—Common Council is completing plans for new municipal electric light and power plant. A bond issue of $88,000 has been authorized. Diesel engine-generating units will be used. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

Ky., Louisville — Glencoe Distillery Co., 723 South Twenty-sixth Street, plans installation of electric power equipment in new plant on Cane Run Road, where site has been acquired. A boiler house will be built. Entire project will cost close to $125,000.

Md., Ocean City — Ocean City Chamber of Commerce is at head of project to construct a municipal electric light and power plant. Proposed to arrange a bond issue of $150,000 for project.

Minn., Duluth—Pigeon River Lumber Co., care of John Jenswold, Jr., Palladio Building, Duluth, attorney and representative, plans new hydroelectric power project on Pigeon River at Northern boundary of Cook County, Minn., including series of power dams, main hydroelectric generating station, power substations, transmission lines and other structures for power service at lumber and wood pulp mills. Entire project will cost about $2,500,000. Application has been made to Federal Power Commission for permission. D J. Arpin, Wisconsin Rapids, Wis., is president.

N. J., North Bergen—New York Revolving Portable Elevator Co., 333 Garfield Avenue, Jersey City, N. J., plans installation of electric power equipment in new one-story plant on State Street, North Bergen, where site has been acquired. Entire project is reported to cost about $50,000.

N. Y., Lackawanna — Bethlehem Steel Co., South Bethlehem, Pa., plans installation of electric power equipment in new steel sheet and strip mill at works at Lackawanna, near Buffalo. Entire project will cost close to $15,000,000, and will be carried out during 1935. Company will also make extensions and improvements in Cambria mills, Johnstown, Pa., with installation of electric power and other equipment. Cost about $500,000. Company engineering department is in charge.

N. Y., New York—Department of Public Markets, Municipal Building, plans installation of electric power equipment, refrigerating machinery and other equipment in new additions to Bronx Terminal Market, Exterior Street, Bronx. Cost about $300,000. A building permit has been issued. Oxhandler & Lewis, 250 Park Avenue, New York, are architects.

N. Y., New York—Procurement Division, Public Works Bureau, Treasury Department, Washington, D. C., has secured fund of $3,780,000 for construction of new electric generating plant at New York for electric light and power service for group of 12 Federal buildings, recently referred to in these columns, and will have plans drawn at early date. Project will include main generating station, power substations, transmission and distribution lines, underground conduit system, service facilities, etc.

N. Y., Rochester—Rochester Gas & Electric Corporation will make extensions and improvements in main steam-operated electric generating plant, including installation of new turbo-generator unit and auxiliaries, high-pressure boiler and accessory equipment. Work will begin early in the spring. Cost about $1,000,000. Company engineering department is in charge.

N. Y., Waterloo—Waterloo Mills, Inc., plan installation of electric power equipment for expansion and modernization program at woolen mills. Plant has been idle for number of months. Financing for $315,000 is being arranged through Federal aid, of which about $200,000 will be used for purpose noted. H. M. Buttery is manager.

Ohio, Mount Vernon — Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa., plans installation of power equipment in connection with expansion and improvemens in branch sheet glass works at Mount Vernon, designed to double present capacity. Entire project will cost about $750,000. General contract has been awarded to the Rust Engineering Co., Koppers Building, Pittsburgh.

Ohio, Wauseon—Winnorr Canning Co., Circleville, Ohio, Howard Orr, president, plans installation of electric and steam power equipment in proposed new food canning plant at Wauseon, where site has been acquired. Entire project is reported to cost over $35,000.

Ont., Toronto—Arntfield Gold Mines, Ltd., Frederick S. Artfield, president, plans installation of electric power equipment in new mill at gold mining properties in Northern Ontario. Financing is being completed. Cost over $125,000.

Ont., Toronto—Gold Eagle Gold Mines, Ltd., Toronto, Charles E. St. Paul, president, plans installation of electric power equipment in connection with development of gold-mining properties in Northern Ontario, including hoisting, conveying and other mechanical-handling equipment. Company is carrying out financing for $200,000, considerable portion of fund to be used for purpose noted.

Pa., Hanover—Mummert-Dixon Co., Philadelphia Street, manufacturer of portable grinders, etc., plans installation of electric power equipment in connection with rebuilding of portion of plant, recently destroyed by fire. Loss over $75,000.

Pa., Meadville — Hookless Fastener Co., Meadville, plans installation of electric power equipment in new three and four-story addition to local metal products plant, 60x300 ft. Entire project will cost about $350,000. Wilbur Watson & Associates, 4614 Prospect Avenue, Cleveland, Ohio, are architects.

Pa., Philadelphia—John Knoell & Sons, 171 West Jefferson Street, plan installation of electric power equipment in connection with rebuilding of portion of furniture factory, recently destroyed by fire. Loss about $50,000.

Tenn., Chattanooga — Tennessee Electric Power Co., Chattanooga, is arranging fund of $350,000 for extensions in transmission lines and distributing system, including power substation facilities, etc., for electric light and power service in new districts during 1935.

Tenn., Memphis — Plough, Inc., Memphis, is having plans drawn for new multi-story plant on East Parkway, for manufacture of chemical specialties, cosmetics, etc. Electric power equipment will be installed. A boiler plant will be built. Proposed to ask bids on general contract in March. Hanker & Cairns, 123 South Court Street, Memphis, are architects; Arthur L. Nelson Engineers, Inc., 31 St. James Avenue, Boston, Mass., is consulting engineer. Entire project will cost over $500,000.

Texas, Wichita Falls—City Council is planning new municipal electric light and power plant. Cost estimated at $2,000,000, including power substation and distribution lines. Financing will be arranged at early date. City engineering department will be in charge.

Va., Luray—Luray Ice Co. is planning early rebuilding of portion of ice-manufacturing plant recently destroyed by fire. Loss about $25,000, including equipment.